July 08, 2024

Geotechnical Investigation and Design Report

TN ERFO FS CHRKE804 2020-2(2)

Rehabilitation of McFarland Road (FS 23)
Slope Failures at MP 9.245, MP 10.189, MP 10.378
Cherokee National Forest, Polk County, Tennessee

Contact No.: 693C7321D000005
Task Order: 693C7323F00085N
JMT No.: 19-01472-007

Prepared For:

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July 08, 2024

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Re: Geotechnical Investigation and Design Report
TN ERFO FS CHRKE804 2020-2(2)
McFarland Road, Cherokee National Forest, Tennessee.
Design Services to Rehabilitate Sites at MP 9.245, 10.189, and 10.378, McFarland Road (FS 23)
Contact No.: 693C7321D000005
Task Order: 693C7323F00085N
JMT Job No.: 19-01472-007

Dear Mr. Weston:

Johnson, Mirmiran & Thompson, Inc. (JMT) is pleased to submit this Geotechnical Investigation and Design Report for the above referenced project. This report contains a discussion of our understanding of the project, exploration procedures, the exploration results, and the recommendations for the design and construction of the proposed repairs at MP 9.245, 10.189, and 10.378 on McFarland Road (FS 23), Tennessee.

It has been our pleasure to be of service to the Eastern Federal Lands Highway Division (EFLHD). If you have any questions or require any additional information, please do not hesitate to contact this office.

Very truly yours,

JOHNSON, MIRMIRAN & THOMPSON, INC.

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MCFARLAND ROAD
GEOTECHNICAL INVESTIGATION AND DESIGN REPORT

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1.0 INTRODUCTION

1.1 General

As authorized by our agreement with the Federal Highway Administration's Eastern Federal Lands Highway Division (FHWA-EFLHD), Johnson, Mirmiran & Thompson, Inc. (JMT) has completed this Geotechnical Investigation and Design Report (GDR) for the design and construction of the proposed rehabilitation of three distressed slopes on McFarland Road (FS 23), at Milepost (MP) 9.245, 10.189, and 10.378, within the Cherokee National Forest, Tennessee. The site location map is included in Appendix A.

1.2 Background

McFarland Road (FS 23) is within the limits of the Cherokee National Forest, Polk County, Tennessee. The road is a single lane12 to 14 feet wide, crushed stone surfaced roadway with no shoulders. There are a number of widened areas where vehicles can pass.

Heavy rain events caused roadway damage to a number of sites on McFarland Road. The three sites that are the subject of this report are located at MP 9.245 (Pin 365), MP 10.189 (Pin 370), and MP 10.378 (Pin 371). These sites are also identified by Pin numbers in the *CherokeeMaster_Pin Final kml* file supplied with the client data for this task. All three sites were originally constructed with one side of the road cut into the face of the mountain and the other roadside constructed on fill. The failures consist of the downslope fill side slipping away which results in a narrow treacherous roadway. The length of the failure at all slide locations is approximately 80 feet. The General Plans for proposed improvements are included in Appendix A of this report.

1.3 Scope of Work

The scope of JMT's services on this project consists of exploring the subsurface conditions using soil borings, laboratory testing of soil and rock samples, evaluating the subsurface conditions development of geotechnical recommendations and submittal of our findings in this report.

The project is being designed using the Load and Resistance Factor Design (LRFD) methodology and the geotechnical analysis was performed in accordance with the AASHTO LRFD Bridge Design Specifications, 9th Edition, 2020.

1.4 Purpose of Report

The purpose of this report is to provide the results of the general subsurface exploration at the location of the sites and the evaluation of those conditions with respect to geotechnical engineering recommendations to aid in the design and construction of the proposed repairs. The geotechnical engineering recommendations presented in this report are based on JMT's geotechnical engineering analysis of the subsurface conditions indicated by the test borings.

2.0 GEOLOGIC SETTING

The project locations are within the Blue Ridge Physiographic Province. The Blue Ridge is described as a 550-mile-long belt of Appalachian Mountains that extends from Pennsylvania to Georgia. In this area, the Blue Ridge is represented by the Great Smokey Mountains. The topography is described as ridges and rolling hills. All three sites are at the base of Smith Mountain with MP 9.245 on the west and MP 10.189 and MP 10.378 on the east side.

The slope in the area of MP 9.245 faces northwest and surface drainage is to the Hiwassee River which is to the northwest of the slope. There is an active excursion railroad at the base of the slope. This line is believed to be operated by the Tennessee Valley Railroad.

The slopes at MP 10.189 and MP 10.378 face east, and surface drainage in those areas is towards Wolf Creek. Wolf Creek flows north to the Hiwassee River. Some or all of the site at MP 10.378 may be within the Right-of Way of the TVA Apalchia Tunnel. This tunnel, constructed during WWII to provide waterpower to a hydroelectric plant located about 3.5 miles west of MP 10.378, and named after the town of Apalachia, TN is listed on the National Register of Historic Places.

According to the *Geologic Map of Tennessee (East-Central Sheet), Hardman, Miller, and Swingle, 1966, Tennessee Division of Geology*, the three sites are underlain by members of the Precambrian Age Great Smokey Group. The Great Smokey is described as massive layers of coarse graywacke and arkose. The sediments are folded and fractured. The site geologic map is provided in Appendix A.

According to the *Geologic Map of southwestern North Carolina including adjoining southeastern Tennessee and northern Georga, Weiner, L.S., and Merschat, C.E., North Carolina Geological Survey, 1992*. The closest published reading for the strike and dip of the formation layers is N 40° E and 82°SE, respectively This results in the rock dipping into the slope face for MP 9.245 and dipping out of the slope face for MP 10.189 and MP 10.378.

3.0 SUBSURFACE EXPLORATION PROGRAM

3.1 Subsurface Exploration

Seven soil test borings, designated FS 23-B1 through FS 23-B7, were drilled at three sites by S&ME, Inc. of Louisville, Tennessee, between January 23, 2024, and January 25, 2024. The locations of the borings are indicated on the Roadway Plan sheet included in Appendix A of this report.

3.2 Field Testing and Sampling

The borehole was performed with a track-mounted drill rig, using a 4-inch ID casing-advancer to advance the borehole. S&ME provided full-time supervisors for the field investigation, including drilling inspectors and an on-site geologist knowledgeable of standard test boring procedures and the soil and rock sampling requirements of the AASHTO. The geologist and drilling team worked under the supervision of a Professional Engineer. Representative soil samples were obtained by means of the split-barrel sampling procedure in general accordance with ASTM D 1586. In the split-barrel sampling procedure, a 2-inch O.D. split-barrel sampler is driven into the soil a distance of 18 or 24 inches by means of an automatic 140-pound hammer falling 30 inches. The number of hammer blows required to drive the sampler through a 12-inch interval is termed SPT value (blow count, or N-value) and is indicated for each sample on the Boring Log. The SPT was performed using an automatic hammer. A representative portion of each SPT sample was placed in a glass jar and appropriately marked.

Rock coring was accomplished in general accordance with ASTM D2113. Rock coring commences when the boring can no longer be advanced using the casing-advancer. A double tube NQ Series core barrel and bit were employed. As the core barrel is advanced through the rock, the bit is cooled with water which also removes the cuttings. The inner barrel protects the core sample from erosion. The resulting rock core is a nominal 2 inches in diameter. The core sample is boxed and measured. The length of the sample is measured and reported as a percentage of the run. Rock Quality Designation (RQD) is measured in accordance with ASTM D6032, where the sum of the lengths of unweathered core pieces equal to or greater than 4 inches is reported as a percentage of the total run. After drilling and measuring the water level, each borehole was filled with grout.

Groundwater levels were measured in the borings before the coring commenced and after drilling. The results of the groundwater readings are shown on the test boring logs. Groundwater data is discussed further in Section 4.2 of this report.

Table 1 summarizes the locations and depths of the completed borings. JMT precisely located all the borings and tied the geographic position to the project's survey datum, State Plane Coordinate System (NAD83/2011), and North American Vertical Datum of 1988 (NAVD88). The boring location plan and boring logs are included in Appendix A and B of this report, respectively.

Table 1: Soil Borings Along McFarland Road FS 23				
Milepost (Pin Number)	**No. of Borings**	**Boring ID**	**Boring Depth (feet)**	**Rock Coring (feet)**
9.245 (Pin 365)	2	FS 23 - B1	50.6	15.4
		FS 23 - B2	20.5	14.5
10.189 (Pin 370)	3	FS 23 - B3	15	9.7
		FS 23 - B4	10.5	9.6
		FS 23 - B5	14	11
10.378 (Pin 371)	2	FS 23 - B6	16.6	14.9
		FS 23 - B7	12.4	9.4

3.3 Laboratory Testing

The representative samples of soils encountered in the subsurface exploration were tested for natural moisture contents, Atterberg Limits, grain size (sieve), and soil classification to understand the engineering properties of the soils. Laboratory testing was performed in accordance with the appropriate AASHTO and ASTM guidelines. Table 2 summarizes the soil test results.

Table 2: Soil Laboratory Tests								
Boring	**Depth**	**Moisture (%)**	**Atterberg Limits**			**% Fines**	**USCS Classification**	**AASHTO Classification**
			LL	PL	PI			
FS 23-B1	2	20.4	30	26	4	58.0	ML	A-4,1
FS 23-B1	8.5	8.3	30	28	2	56.9	ML	A-4,0
FS 23-B1	18.5	8.0	31	29	2	64.7	ML	A-4,1
FS 23-B2	2	19.8	29	24	5	66.8	ML	A-4,2
FS 23-B2	4	4.1	29	26	3	35.6	SM	A-4,0
FS 23-B3	0	14.8	26	21	5	28.3	SC-SM	A-2-4,0
FS 23-B3	2	20.8	26	19	7	26.9	SC-SM	A-2-4,0
FS 23-B3	4	5.2	24	19	5	21.0	SC-SM	A-1-b,0
FS 23-B6	0	3.5	34	23	11	24.7	SC	A-2-6,0

Representative samples of rock core from the borings were subjected to testing for unconfined compressive strength. Table 3 below summarizes the test results.

Table 3: Rock Tests – Unconfined Compression

Boring	Depth	Unit Weight (pcf)	Unconfined Compression (psi)	Classification
FS 23-B2	20.0-20.4	172.8	13,924	Slate
FS 23-B3	5.6-6.0	166.2	32,730	Graywacke
FS 23-B4	4.8-5.2	168.5	28,372	Graywacke
FS 23-B6	7.98.3	175.7	5,474	Slate
FS 23-B7	3.5-3.9	174.4	1,260	Slate

Conducted soil corrosion tests on representative soil samples, analyzing pH, resistivity, and chloride and sulfate content. The summarized test results are presented in Table 4 below.

Table 4: Chemical Tests Results

Boring	Depth (ft)	pH	Sulfates (SO_4)		Chloride (CL)		Resistivity (ohm-cm)		Classification
			(mg/kg)	(%)	(mg/kg)	(%)	Received	Minimum	
FS 23-B1	13.5-15	8.9	2.3	0.0002	5.0	0.0005	36,180	27,470	SILT (ML)
FS 23-B5	1-3	7.2	33.2	0.0033	6.6	0.0007	63,000	13,050	Poorly Graded GRAVEL (GP)
FS 23-B7	1-3	6.8	554.0	0.0554	34.4	0.0034	21,000	2,550	Poorly Graded SAND (SP)

The potential acidity test was performed in accordance with U.S. Environmental Protection Agency (EPA) guidelines EPA-600/2-78-054, and the results are presented in Table 5. Other test results, such as sulfur content and neutralization potential, can be found in Appendix B.

Table 5: Potential Acidity Tests Results

Boring	Sample ID	Sample Depth	Test	Value	Unit
FS-23-B5	Run-3	13.0 to 13.4 ft	Potential Acidity	7.94	Ton $CaCO_3$/T Ton

Any untested soil samples and rock cores will be sent to the FHWA EFLHD Laboratory in Sevierville, Tennessee

4.0 SUBSURFACE CONDITIONS

4.1 General

The subsurface conditions at the site were analyzed by utilizing data from the seven test borings performed for the three sites. Borings FS 23-B1, FS 23-B2, FS 23-B3 FS 23-B5 and FS 23-B6 were drilled in the crushed aggregate surfaced roadway which ranged from 1 to 11 inches thick. The boring FS 23-B4 was drilled by the side of the road and encountered residuum at the surface. Boring FS 23-B7 encountered one (1) inch of topsoil.

All seven borings were advanced into rock which was encountered directly below the residual soils. The rock is described as SLATE and GRAYWACKE. Slate may generally be considered as a low grade of metamorphosed shale. Graywacke may be considered as an impure sandstone. The impurities consist of silt and clay sized micaceous and chlorotic minerals. Boring plans and log are included in Appendix A and B, respectively. The generalized subsurface profiles are included in Appendix C. The stratification lines shown on the profiles represent approximate transitions between material types at the location of the borings. Note that in-situ strata changes could occur gradually or at slightly different levels between the borings. Also, the borings depict conditions at the boring location and particular times indicated. Some conditions, particularly groundwater conditions between borings could vary from the conditions encountered at the particular boring locations.

The borings indicated the subsurface conditions below the aggregate surface and topsoil consisted of the following materials:

4.1.1 MP 9.245 (Borings FS 23-B1 and FS 23-B2)

Residuum

Residual soils were encountered beneath the crushed aggregate road surface in both borings. The residual soils generally consisted of SILT (ML), little sand. Rock fragments were found in some samples. The relic structure of the parent slate was noted in most samples. The residual soils extended down to the depth of 35.2 at elevation EL 1014.85 in boring FS 23-B1 and to the depth of 6 feet at elevation EL 1040.765 in boring FS 23-B2.

The N-values from SPTs for the fine-grained soils generally ranged from 7 to 31 blows per foot (bpf), which indicated medium stiff to hard consistencies.

Rock

Rock was encountered at the depth of 35.6 feet, EL 1014.45 in boring FS 23-B1 and at the depth of 6 feet, EL 1040.765 in boring FS 23-B2. The rock is described as blue slate in both borings. Run #1 in boring FS 23-B1 was only 4.8 inches and is described as an incompetent slate and therefore is not included in the core recovery and RQD averages. Core recoveries ranged from 32% to 80% and averaged 48%. RQD ranged from 0% to 16% and averaged 6%.

4.1.2 MP 10.189 (Borings FS 23-B3 to FS 23-B5)

Residuum

Residual soils were encountered beneath the crushed aggregate road surface in all three borings. The residual soils generally consisted of Silty, Clayey SAND (SC-SM) with gravel and Poorly Graded GRAVEL (GP) with sand. The depths to the bottom of the residuum ranged from 0.9 feet to 5.6 feet. Elevations of the bottom of the residuum ranged from EL1136.95 to EL 1143.08.

The N-values from SPTs for the coarse-grained soils for the residuum generally ranged from 5 bpf to 50 blows for 3 inches of penetration indicating loose to very dense relative densities.

Rock

Rock was encountered at the depths of 0.9 feet to 6 feet. The elevations of the top of rock ranged from EL1136.95 to EL 1143.08.

The rock is described as graywacke in borings FS 23-B3 and FS 23-B4. The 30-inch Run#1 of boring FS 23-B5 was described as slate. Beneath the slate the rock was described as graywacke. Core recoveries ranged from 40% to 100% and averaged 81%. RQD ranged from 0% to 88% and averaged 48%.

A subsurface void was reported from 7.2 feet to 9.9 feet in boring FS 23-B3. The run that measured as 0% RQD was the slate from Run#1 in boring FS 23-B5.

4.1.3 MP 10.378 (Borings FS 23-B6 and FS 23-B7)

Residuum

Residual soils were encountered beneath the crushed aggregate road surface in boring FS 23-B6 and the topsoil of boring FS 23-B7. The residual soils generally consisted of Clayey SAND (SC) with gravel and Poorly Graded SAND (SP) with gravel. The depths to the bottom of the residuum ranged from 1.7 feet to 3 feet. Elevations of the bottom of the residuum ranged from EL1180.9 to 1185.46.

The N-values from SPTs for the coarse-grained soils for the residuum generally ranged from 23 bpf to 50 blows for 3 inches of penetration indicating medium dense to very dense relative densities.

Rock

Rock was encountered at the depth of 1.7 feet, EL 1180.9 in boring FS 23-B6 and at the depth of 3 feet, EL 1185.46 in boring FS 23-B7. The rock is described as blue slate in both borings. Core recoveries ranged from 83% to 100% and averaged 94%. RQD ranged from 26% to 100% and averaged 78%.

4.2 Groundwater Conditions

The groundwater levels recorded on the logs were measured after the drilling operations. The depths and elevations of the groundwater are shown in Table 6. Groundwater readings were not taken for Boring FS 23-B3 due to surface water running into the borehole. It should be noted that groundwater levels could fluctuate with changes in seasonal conditions. The recorded water levels, or absence of water, reflect the conditions

at the time of this exploration only. Fluctuations in the location of hydrostatic groundwater level and perched water levels can occur as a result of seasonal variations in evaporation, precipitation, surface water run-off, and other factors. Some conditions, particularly groundwater conditions between borings, could vary from the conditions encountered at the particular boring locations.

Table 6: Groundwater Levels Along McFarland Road FS 23

Milepost (Pin Number)	Boring ID	Groundwater Before Coring	Groundwater After Completion		Groundwater Elevation (feet)
			Hours After	Depth (feet)	
9.245 (Pin 365)	FS 23 - B1	Not Encountered	48	Not Encountered	-
	FS 23 - B2	Not Encountered	48	Not Encountered	-
10.189 (Pin 370)	FS 23 - B3	Not Encountered	-	Not Measured	-
	FS 23 - B4	Not Encountered	48	1.3	1142.68
	FS 23 - B5	Not Encountered	24	6	1138.98
10.378 (Pin 371)	FS 23 - B6	Not Encountered	24	4.5	1178.10
	FS23 - B7	Not Encountered	24	3	1185.46

5.0 GEOTECHNICAL ANALYSIS AND RECOMMENDATIONS

Recommendations regarding proposed rehabilitation of three distressed slopes on McFarland Road (FS 23) at MP 9.245, MP 10.189 and MP 10.378 are presented herein.

5.1 Design Alternatives

A riprap revetment was first considered for these sites based on its lowest cost and ease of construction. However, based on subsurface conditions, field reconnaissance information, and the physical attributes of the sites, the use of the revetment alternative was found to be inadequate. Due to the presence of a stream or the railroad at the base of slope, there is not enough room for the footprint of the 1.5H:1V slope needed to insure long term stability.

Alternatives being considered for stabilization techniques to mitigate existing and future roadway embankment failures at the proposed site locations:

1. Cast-in-Place (CIP) Retaining Wall supported on rock.
2. Gabion Basket Wall.
3. Mechanically Stabilized Earth (MSE) Wall.
4. T-Wall.
5. Modular Block Wall.

Based on engineering judgment, CIP type walls were not considered due to anticipated construction time and costs. Generally, T-wall and MSE wall constructions are more expensive compared to gabion walls and modular block walls. Unlike modular block walls, gabion basket metal mesh has a history of rusting which results in failure and requires regular maintenance. Therefore, JMT recommends the use of a Modular Block Wall for the proposed stabilization at all three sites.

5.2 Seismic Design Considerations

The subsurface exploration findings were utilized to determine the Seismic Site Class for the project sites according to Table 3.10.3.1-1 of AASHTO. The SPT N-values of soil samples were used in classifying the project site, which is classified as Seismic Site Class C. The current AASHTO Bridge Design Specifications (2020) stipulate a design seismic event with a 7 percent probability of occurrence in 75 years, roughly equivalent to a 1000-year return period. The peak seismic ground acceleration (PGA) at the project sites for this specified return period was calculated to be 0.178g for Site Class C. The 0.2 Second Horizontal Response Spectral Acceleration SD_S is 0.324g, and the 1 Second Horizontal Response Spectral Acceleration SD_1 is 0.117g. Seismic Zone classification of the project sites based on Acceleration Coefficient SD_1 is presented in Table 3.10.6-1 of the AASHTO. With an SD_1 value of 0.117g, the project sites fall within Seismic Zone 1. Detailed seismic results can be found in Appendix D.

Per ASHTO 11.5.4.2, seismic design is not mandatory for retaining walls in Seismic Zone 1 where the peak ground acceleration (PGA) is less than or equal to 0.4g. Consequently, neither external nor internal seismic

evaluations are needed for the proposed retaining walls. However, an Extreme Event I global stability analysis is required for all sites.

5.3 Proposed Retaining Walls at MP 9.245 (Pin 365), MP 10.189 (Pin 370) and MP 10.378 (Pin 371)

Based on field observations and the results of subsurface exploration programs, it is recommended to use retaining walls to stabilize the landslide at all three locations. Table 7 provides the location and maximum wall height.

Table 7: Proposed Retaining Wall Locations

Milepost (Pin Number)	Station		Proposed Roadway Grade Elevation (feet)	Approx. Max. Wall Height (feet)
	From	To		
9.245 (Pin 365)	2+00	2+80	1048	15
10.189 (Pin 370)	4+80	5+60	1144	10
10.378 (Pin 371)	9+00	9+80	1184	10

The proposed walls will be around 80 feet in length, with a maximum height of 15 feet at MP 9.245 and 10 feet at MP 10.189 and MP 10.378. The proposed walls are planned to be constructed using Redi-Rock prefabricated gravity concrete blocks or equivalent modular block wall. The proposed retaining walls will be constructed on the existing slopes and a minimum horizontal bench width of 4 feet shall be provided in front of the proposed walls.

The internal stability design of the proposed Redi-Rock or equivalent wall should be the responsibility of an approved specialty wall contractor who is a registered professional engineer licensed in the State of Tennessee and reviewed by the Engineer. The Contractor should use the established soil profile and soil parameters included in the report. The specialty wall contractor should provide design computations and plans for the proposal walls. All design computations should be in accordance with AASHTO LRFD Bridge Design Specifications 9th Edition, 2020. The wall should be designed for a minimum design life of 75 years. The backfill behind the proposed wall should consist of free draining, granular backfill meeting requirements for AASHTO Porous Fill (No. 57 Stone). The No. 57 stone should meet the requirements stated in Section 704 of Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects, FP-14 (FP-14).

5.3 Soil/Rock Design Parameters

Tables 8 to 10 present the representative soil/rock properties for the generalized subsurface profiles at the sites of MP 9.245, MP 10.189 and MP 10.378, respectively. These properties were utilized in evaluating the foundations for the proposed structures.

Table 8: Summary of Recommended Soil Parameters for MP 9.245 (Pin 365)

Stratum	Unit Weight, γ_{sat} (pcf)	Cohesion, C' (psf)	Friction Angle, ϕ' (°)
Residuum	125	0	34
Rock - Slate	170	1000	30
AASHTO NO. 57 Stone	110	0	38
Riprap	110	0	45

Table 9: Summary of Recommended Soil Parameters for MP 10.189 (Pin 370)

Stratum	Unit Weight, γ_{sat} (pcf)	Cohesion, C' (psf)	Friction Angle, ϕ' (°)
Rock – Slate/Graywacke	170	1000	30
AASHTO NO. 57 Stone	110	0	38
Riprap	110	0	45

Table 10: Summary of Recommended Soil Parameters for MP 10.378 (Pin 371)

Stratum	Unit Weight, γ_{sat} (pcf)	Cohesion, C' (psf)	Friction Angle, ϕ' (°)
Rock - Slate	170	1000	30
AASHTO NO. 57 Stone	110	0	38
Riprap	110	0	45

5.4 External Stability

External stability for overturning, sliding and bearing capacity for the Redi-Rock Walls were analyzed using the Redi-Rock Walls Analysis Computer Program Version 2024.29 supplied by Redi-Rock International, USA. The proposed walls have a 5-degree batter at the front and a minimum base width of 5 feet. The minimum Capacity Demand Ratio (CDR) for overturning, sliding and bearing capacity should be greater than or equal to 1.0. A uniform distributed live load surcharge of 250 psf was applied along the road to account for traffic loading. The CDR is greater than or equal to 1 and is considered acceptable.

The global stability of the proposed structures were analyzed using the Modified Bishop's Circular Method using Slide 2 program, Rocscience, Inc., Toronto, Canada. A live load surcharge of 250 psf was applied on the roadway. Per AASHTO, a minimum Factor of safety (FS) of 1.3 and 1.1 is required for static and seismic loading conditions, respectively.

5.4.1 MP 9.245 (Pin 365)

Based on field observations and subsurface exploration results, it is recommended to use a Redi-Rock wall to stabilize the landslide at MP 9.245. Weathered rock or bedrock was encountered at a depth of 35.6 feet (EL 1014.45) in boring FS 23-B1 and at a depth of 6 feet (EL 1040.765) in boring FS 23-B2.

The proposed wall is expected to have a maximum height of approximately 15 feet and a base width of 5 feet. The proposed wall will be founded on the existing 1.3H:1V slope, with a minimum horizontal bench width of 4 feet in front of the wall.

The proposed wall can be situated on a residuum near the roadway with level backfill. Alternatively, it can be placed on weathered rock at EL 1015, with a 1.5H:1V rip-rap back slope above the wall.

There are two issues with placing the wall on residuum: reduced bearing capacity due to the existing slope and the risk of slope instability affecting the foundation. The nominal bearing resistance of the wall founded on residuum on the existing 1.3H:1V slope was evaluated in accordance with AASHTO Section 10.6.3.1.2c. The nominal bearing resistance of the proposed wall founded on residuum is 1.5 ksf. The factored bearing resistance at the strength limit state is 0.675 ksf with a resistance factor of 0.45. The CDR for the wall founded on residuum is 0.2, which is less than 1.0 and therefore not acceptable. The global stability of the proposed wall founded on residuum is 1.17 for static loading, which is less than 1.3 and therefore not acceptable. Bearing capacity and global stability computations are included in Appendix C of this report.

The existing slope is approximately 38 degrees, with weathered rock expected around elevation 1014. To address bearing and global stability concerns, it is recommended to base the proposed wall on this weathered rock. Table 11 outlines the location and maximum height of the wall.

Table 11: Proposed Retaining Wall Locations

Milepost (Pin Number)	Station		Proposed Roadway Grade Elevation (feet)	Top Leveling Pad Elevation (feet)	Approx. Max. Wall Height (feet)	Finish Grade Conditions	
	From	To				Top of Wall	Base of Wall
9.245 (Pin 365)	2+00	2+80	1048	1015	15	1.5H:1V Riprap Ascending slope	1.3H:1V Descending Slope

The proposed wall founded on weathered bedrock materials and should be designed for the strength limit state using a factored bearing resistance of 9 ksf. The factored bearing resistance at the strength limit state is calculated using a resistance factor of 0.45 and nominal bearing resistance of 20 ksf. The bearing resistance calculations are included in Appendix C. As the proposed walls are to be founded on rock, it is anticipated that the vertical settlements of the walls will be negligible. The bearing stratum should be visually inspected to verify the presence of weathered rock. If site conditions differ from the conditions described above, JMT should be notified to evaluate these conditions and provide revised recommendations. In addition, the footings should be founded at a minimum depth of 2.0 feet below exterior finish grade. A sliding resistance factor, Φ_t, of 0.9 was used to the nominal sliding resistance of Redi-rock block. The eccentricity of loading at the strength limit state, based on factored loads, shall not exceed one-third (1/3) of the footing dimension.

The global stability analysis estimated FS for the proposed wall to exceed 1.3 under static loading conditions. The detailed results of the stability analyses can be found in Appendix C.

A pseudostatic global stability analysis was conducted under seismic loading conditions. The calculated global factor of safety for earthquake events is about 0.98 at MP 9.245, which is below the required FS of 1.1. Consequently, the lateral displacement was assessed using the Simplified Newmark Seismic Displacement method. The analysis indicates that the resulting lateral displacement is approximately 1.14 inches, which falls within the allowable limits and is therefore deemed acceptable. The results of the stability analyses are included in Appendix C.

At MP 9.245, the proposed fill slope above the wall will be graded to 1.5:1V to reach roadway grade. It is recommended to use riprap fill slope to avoid surficial instability. Without cohesion, slope stability solutions approach an infinite slope solution with a factor of safety equal to $\tan(\phi)/\tan(\beta)$ with ϕ equal to the friction angle and β equal to the slope angle. The riprap filling materials with a friction angle of 45 degrees can graded at a slope of 1.5H:1V to obtain a required factor of safety of 1.3.

5.4.2 MP 10.189 (Pin 370) and MP 10.378 (Pin 371)

Based on field observations and the results of subsurface exploration programs, it is recommended to use retaining walls to stabilize the landslide at MP 10.189 and MP 10.378 locations. Table 12 provides the location and maximum wall height.

Table 12: Proposed Retaining Wall Locations

Milepost (Pin Number)	Station		Proposed Roadway Grade Elevation (feet)	Top Leveling Pad Elevation (feet)	Approx. Max. Wall Height (feet)	Finish Grade Conditions	
	From	To				Top of Wall	Base of Wall
10.189 (Pin 370)	4+80	5+60	1144	1131	10	Level	0.5H:1V Descending Slope
10.378 (Pin 371)	9+00	9+80	1184	1176	10	Level	0.9H:1V Descending Slope

The proposed walls at MP 10.189 and MP 10.378 will be founded on bedrock materials and should be designed for the strength limit state using a factored bearing resistance of 9 ksf. The factored bearing resistance at the strength limit state is calculated using a resistance factor of 0.45 and nominal bearing resistance of 20 ksf. The bearing resistance calculations are included in Appendix C. As the proposed walls are to be founded on rock, it is anticipated that the vertical settlements of the walls will be negligible. The bearing stratum should be visually inspected to verify the presence of competent rock. If site conditions differ from the conditions described above, JMT should be notified to evaluate these conditions and provide revised recommendations. In addition, the footings should be founded at a minimum depth of 2.0 feet below exterior finish grade. A sliding resistance factor, Φ_t, of 0.9 was used to the nominal sliding resistance of Redi-rock block. The eccentricity of loading at the strength limit state, based on factored loads, shall not exceed one-third (1/3) of the footing dimension.

Based on the global stability analyses, the FS for the proposed walls at MP 10.189 and MP 10.378 were estimated to be in excess of 1.3 for static loading. The results of the stability analyses are included in Appendix C.

The global stability analyses indicate that the FS for the proposed walls at MP 10.189 and MP 10.378 is in excess of 1.1 for seismic loading and therefore are considered to be acceptable. The results of the stability analyses are included in Appendix C.

5.5 Construction Considerations

5.5.1 Excavation Considerations

Excavation at this site is expected to consist of the removal of loose materials on the slopes, and excavations required to construct the proposed retaining walls. Bedrock should be anticipated at the depths as indicated by “casing refusal” in the boring logs. In certain borings, the rock cores revealed low RQD and recovery, thereby suggesting the possibility of layers or ledges of less weathered rock (i.e. intact rock) within the completely weathered rock matrix. During excavation, in some areas, these layers/ledges of intact rock may be seen as large boulders. In some areas, rock was encountered above the proposed depth of excavation. The depth of the rock is anticipated to vary considerably, depending upon the degree of weathering. Hard digging of the residual soil and/or decomposed rock should also be anticipated above the rock surface. The rock/weathered rock could be excavated using special equipment, such as hoe-ram or heavy excavator; or soundless chemical demolition agents (SCDA), hydraulic splitting or by blasting. If blasting is employed, it should comply with Section 205 of the FP-14 guidelines.

5.5.2 Construction Groundwater

Groundwater was found in some borings, indicating its likely presence at depths in proposed excavations. Perched water conditions might occur during wet seasons or after heavy rain or snow melt. The contractor should be ready to manage groundwater if encountered. Excavations for the retaining wall foundations must remain dry, with surface water prevented from entering. Site grading should prevent water ponding in excavations.

5.5.3 Temporary Excavation Support

All excavations must be performed in accordance with applicable Federal, local and OSHA standards, including any temporary support of excavation structures determined to be needed by the contractor for their means and methods of construction.

5.5.4 Soil Erosion and Slope Protection

The soils at and near the surface consisting of sands, silty sands, silts, and silty clay are considered susceptible to erosion. Therefore, all exposed surfaces should be seeded and vegetated to prevent erosion, as soon as possible. Exposed slopes should be protected from erosion in accordance with local sediment and erosion regulations and as described in Erosion and Sediment Control Plans.

6.0 REPORT ASSUMPTIONS AND LIMITATIONS

This report has been prepared to assist the Design Team with evaluating the sites and proposing repairs on McFarland Road (FS 23) at MP 9.245, 10.189, and 10.378, Tennessee. The report scope is limited to recommendations specific to this project and the locations. The project description represents our current understanding of the significant aspects of the proposed improvements relevant to the geotechnical considerations.

The analysis and recommendations contained in this report are based on the data obtained from the test borings performed at the locations indicated on the boring location plans. The report does not account for subsurface variations that could occur at locations not investigated by the test boring. The nature and extent of such variations may only become evident during construction. If subsurface conditions differ from those described in this report, the recommendations must be re-evaluated.

Plans and specifications should be developed to accommodate possible additional costs that may be required for construction or foundations and/or excavation, as recommended in this report. Additional costs may arise due to various factors, such as project needs or resource requirements, extra foundation depth, potential footing redesign, unsuitable fill material, disturbance of subgrades, groundwater, subsurface obstructions, and others. Based on discussions with USFS Forest Managers and maintenance staff, similar repair projects within the forest have experienced challenges with backslope stability during slope repairs, necessitating increased quantities of fill stone material.

7.0 REFERENCES

AASHTO LRFD Bridge Design Specifications, 9th Edition, 2020.

Federal Land Highway Project Development and Design Manual (2018), Federal Highway Administration, Washington, DC.

Design Manual 7.01: Soil Mechanics (1986), Naval Facilities Engineering Command, Virginia.

Design Manual 7.02: Foundations and Earth Structures (1986), Naval Facilities Engineering Command, Virginia.

Geologic Map of Tennessee, (east central sheet), Hardeman, W.D., Miller, R.A., Swingle, G.D. Tennessee Division of Geology, 1966.

Slide2 Modeler, Rocscience, Toronto, Ontario, Canada.

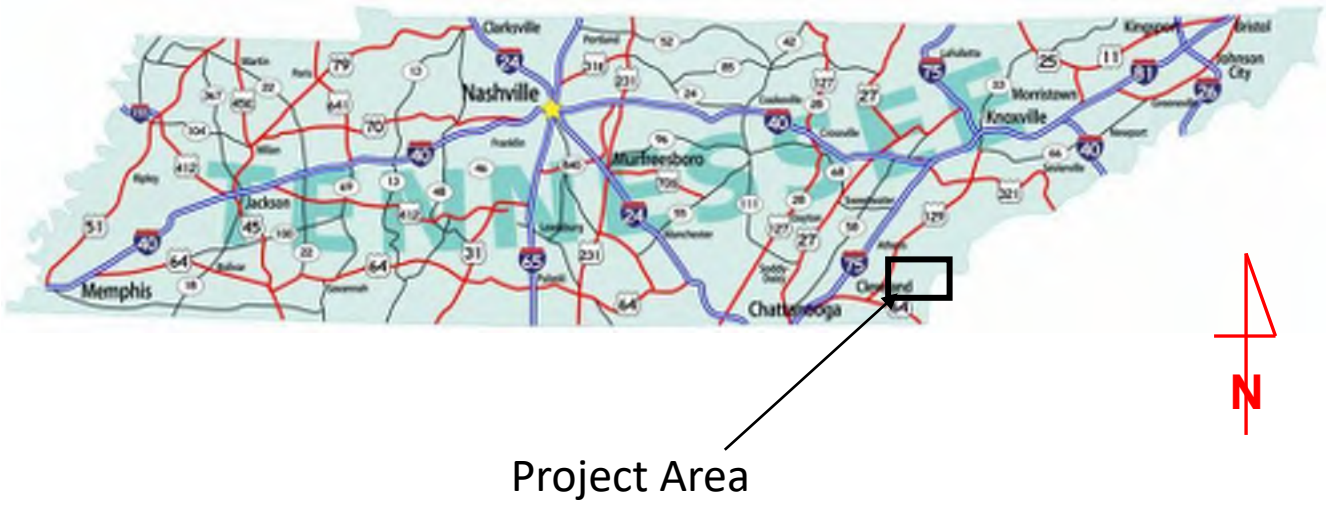
Soils and Foundation (2006), Volume I, Publication No. FHWA NHI-06-088, Washington, DC.

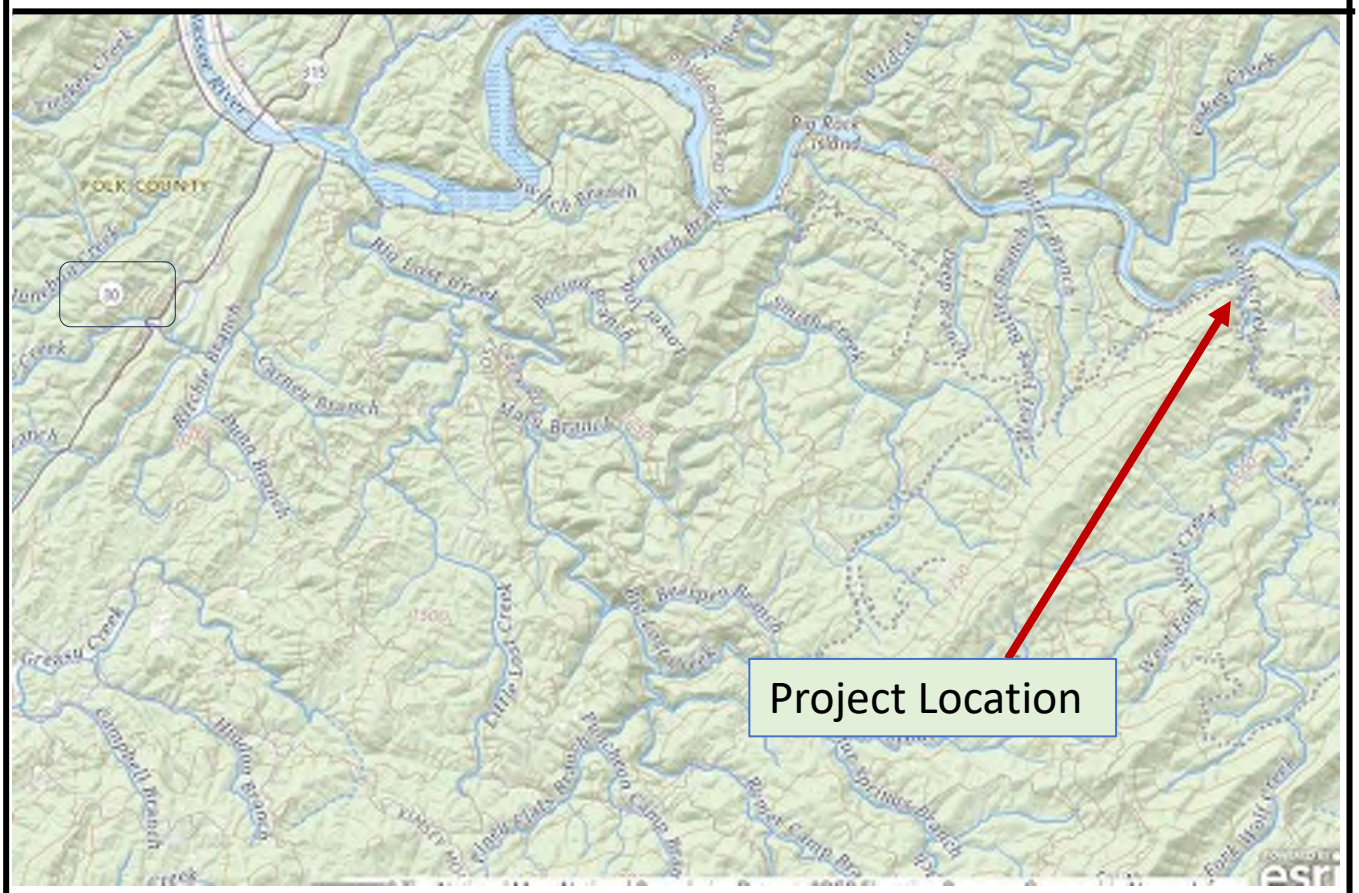
Soils and Foundation (2006), Volume II, Publication No. FHWA NHI-06-089, Washington, DC.

Appendix A

- Site Location Map, Site Geologic Map and General Plans

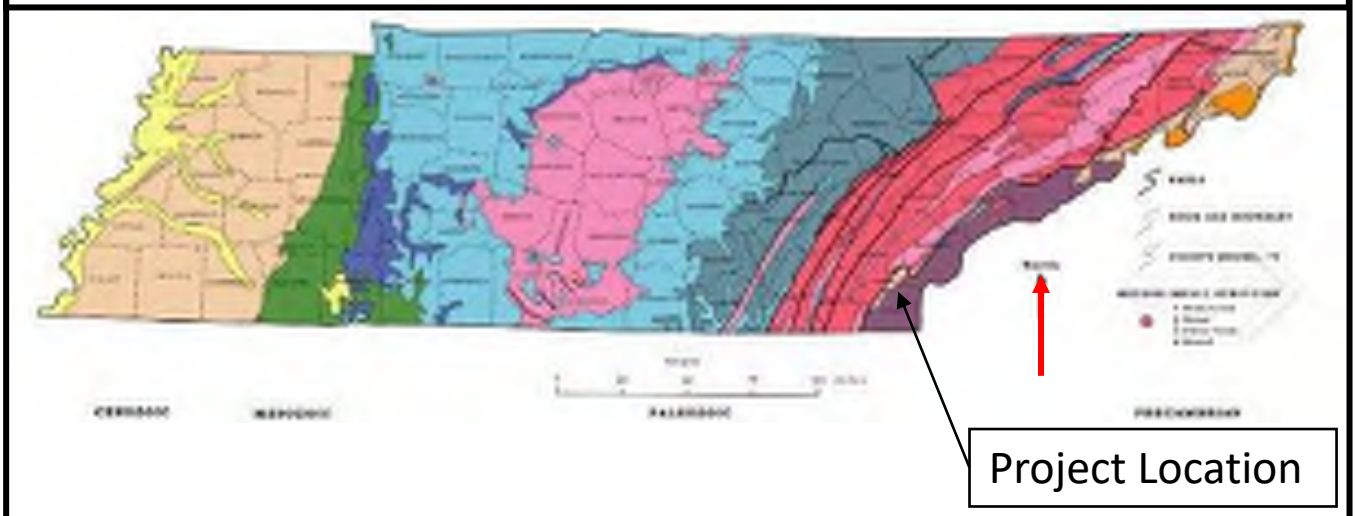
Site Location Map

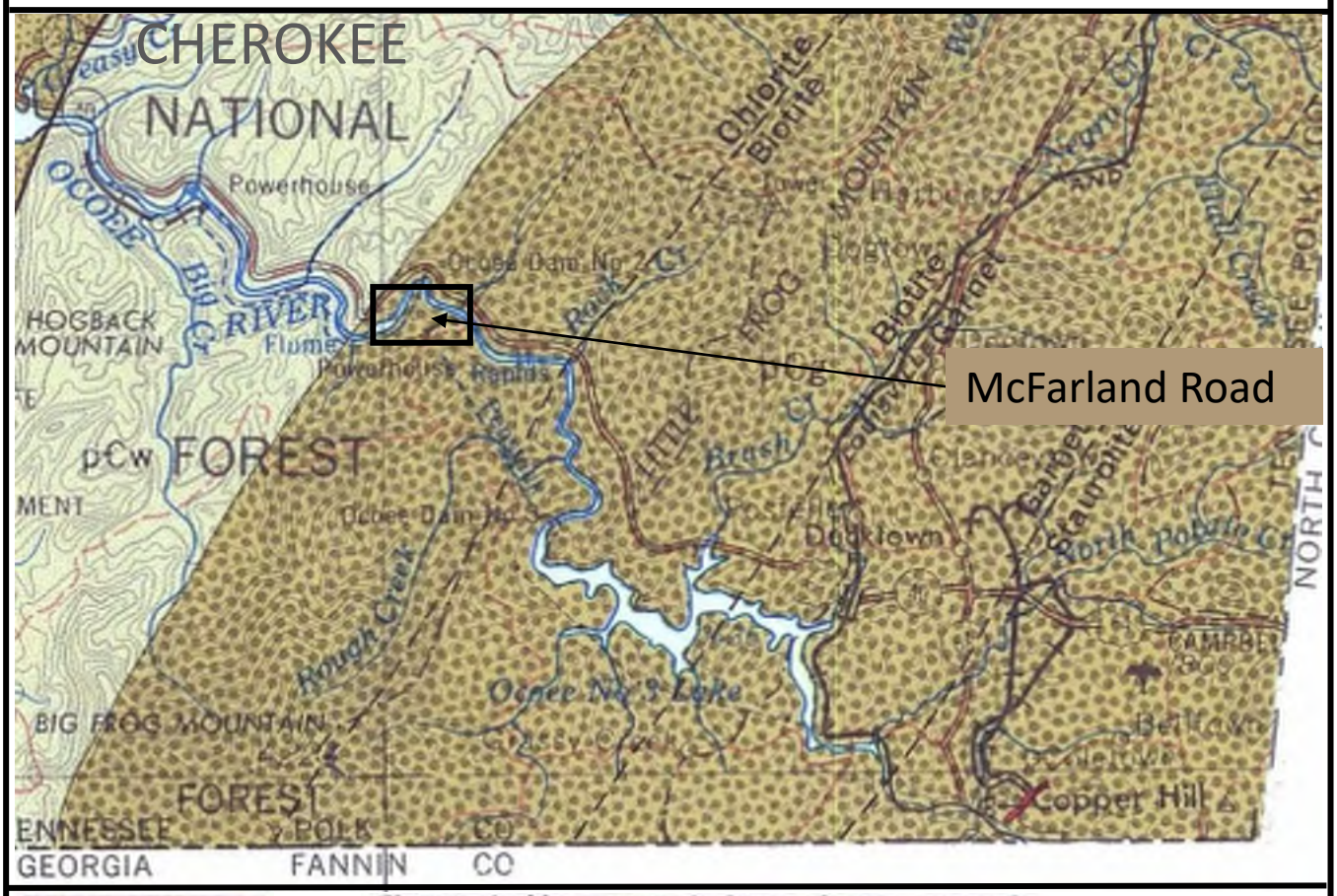




McFarland Road
FS 23
Polk County, Tennessee

Site Geologic Map





Great Smoky Group

Characterized by very massive layers of coarse graywacke and arkose. The formations at right have been mapped only in the region of the Great Smoky Mountains. Near Ducktown, in ascending order, the Copperhill, Hughes Gap, Hothouse, and Dean Formations are recognized. Thickness 14,000 to about 40,000 feet.

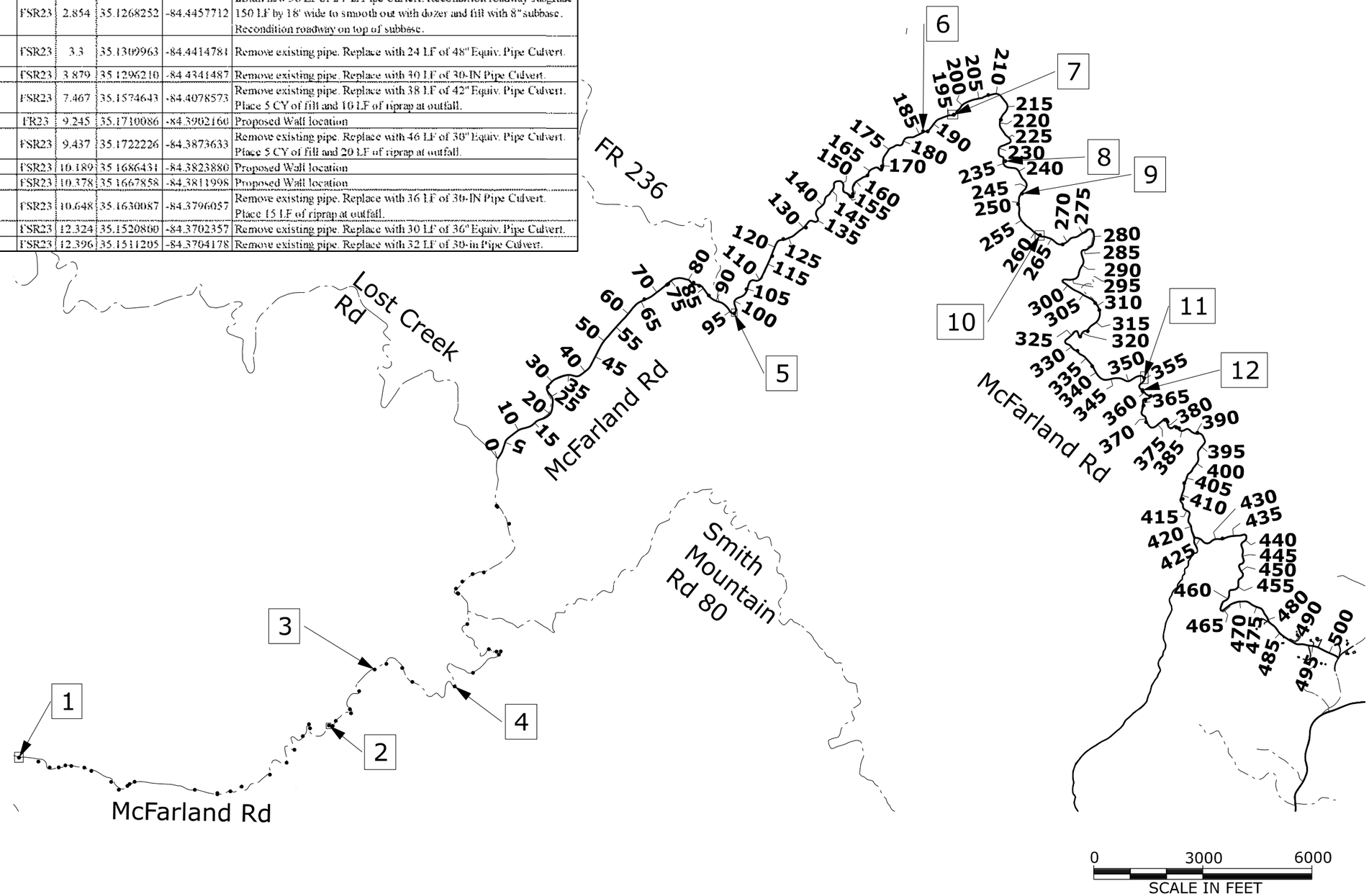
Source: Geologic Map of Tennessee, Miller, Swingle, 1966, Tennessee Division of Geology

McFarland Road
FS 23
Polk County, Tennessee

STATE	PROJECT	SHEET NUMBER

Plan Sheet Locations

Point No.	Master Pin	Route	MP	Latitude	Longitude	SCOPE OF WORK
1	298	FSR23	0.757	35.1247656	-84.4743299	Remove existing pipe. Replace with 32 LF of 36" Equiv. Pipe Culvert
2	322	FSR23	2.854	35.1268252	-84.4457712	Install new 36 LF of 24-In Pipe Culvert. Recondition roadway subgrade 150 LF by 18' wide to smooth out with dozer and fill with 8" subbase. Recondition roadway on top of subbase.
3	328	FSR23	3.3	35.1309963	-84.4414781	Remove existing pipe. Replace with 24 LF of 48" Equiv. Pipe Culvert.
4	332	FSR23	3.879	35.1296210	-84.4341487	Remove existing pipe. Replace with 30 LF of 30-IN Pipe Culvert.
5	354	FSR23	7.467	35.1574643	-84.4078573	Remove existing pipe. Replace with 38 LF of 42" Equiv. Pipe Culvert. Place 5 CY of fill and 10 LF of riprap at outfall.
6	365	FR23	9.245	35.1710086	-84.3902160	Proposed Wall location
7	367	FSR23	9.437	35.1722226	-84.3873633	Remove existing pipe. Replace with 46 LF of 30" Equiv. Pipe Culvert. Place 5 CY of fill and 20 LF of riprap at outfall.
8	370	FSR23	10.189	35.1686431	-84.3823880	Proposed Wall location
9	37	FSR23	10.378	35.1667858	-84.3811998	Proposed Wall location
10	373	FSR23	10.648	35.1630087	-84.3796057	Remove existing pipe. Replace with 36 LF of 30-IN Pipe Culvert. Place 15 LF of riprap at outfall.
11	381	FSR23	12.324	35.1520860	-84.3702357	Remove existing pipe. Replace with 30 LF of 36" Equiv. Pipe Culvert.
12	382	FSR23	12.396	35.1511205	-84.3704178	Remove existing pipe. Replace with 32 LF of 30-in Pipe Culvert.

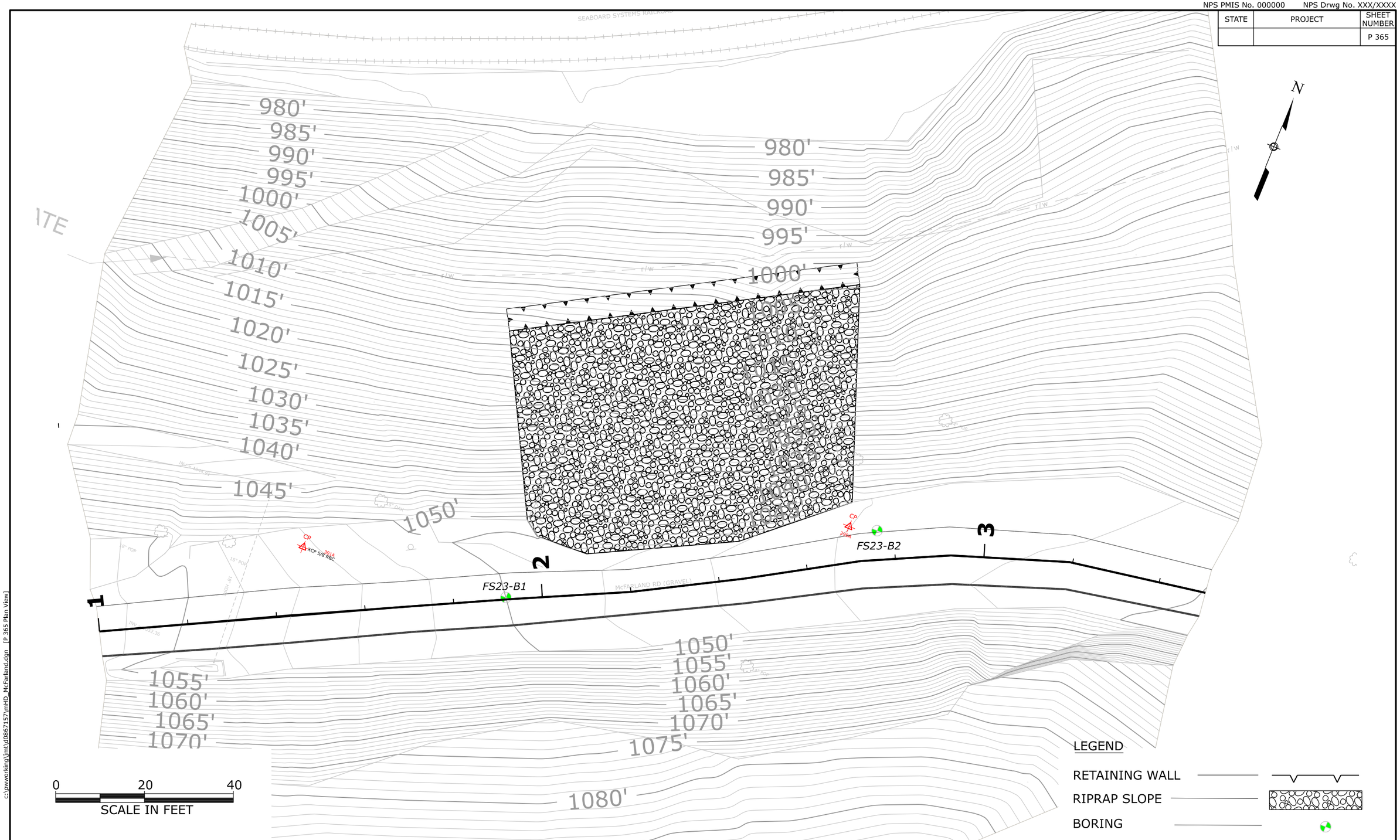


MCFARLAND LOCATION MAP

c:\pwworking\mt\d0867157\mHD_McFarland_Overall.dgn [McFarland Location Map]
13 May 2024 10:36 AM

NPS PMIS No. 000000 NPS Drwg No. XXX/XXXX

STATE	PROJECT	SHEET NUMBER
		P 365

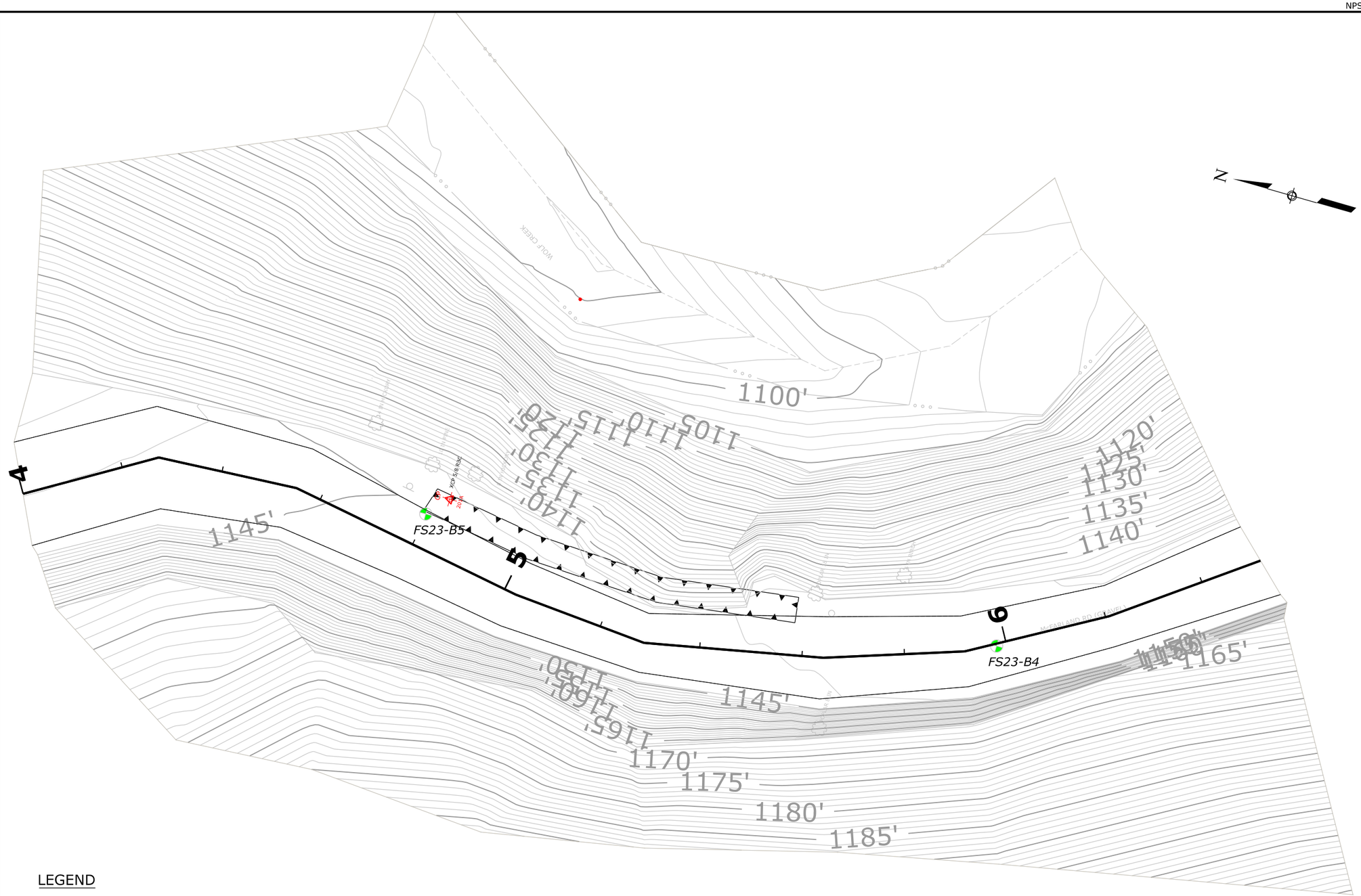


P 365 PLAN VIEW
MILEPOST 9.245

c:\pwworking\jmt\d0867157\mHD_McFarland.dgn [P 365 Plan View]

13 May 2024 10:58 AM

STATE	PROJECT	SHEET NUMBER
		Plan 1



LEGEND

RETAINING WALL

BORING

0 20 40

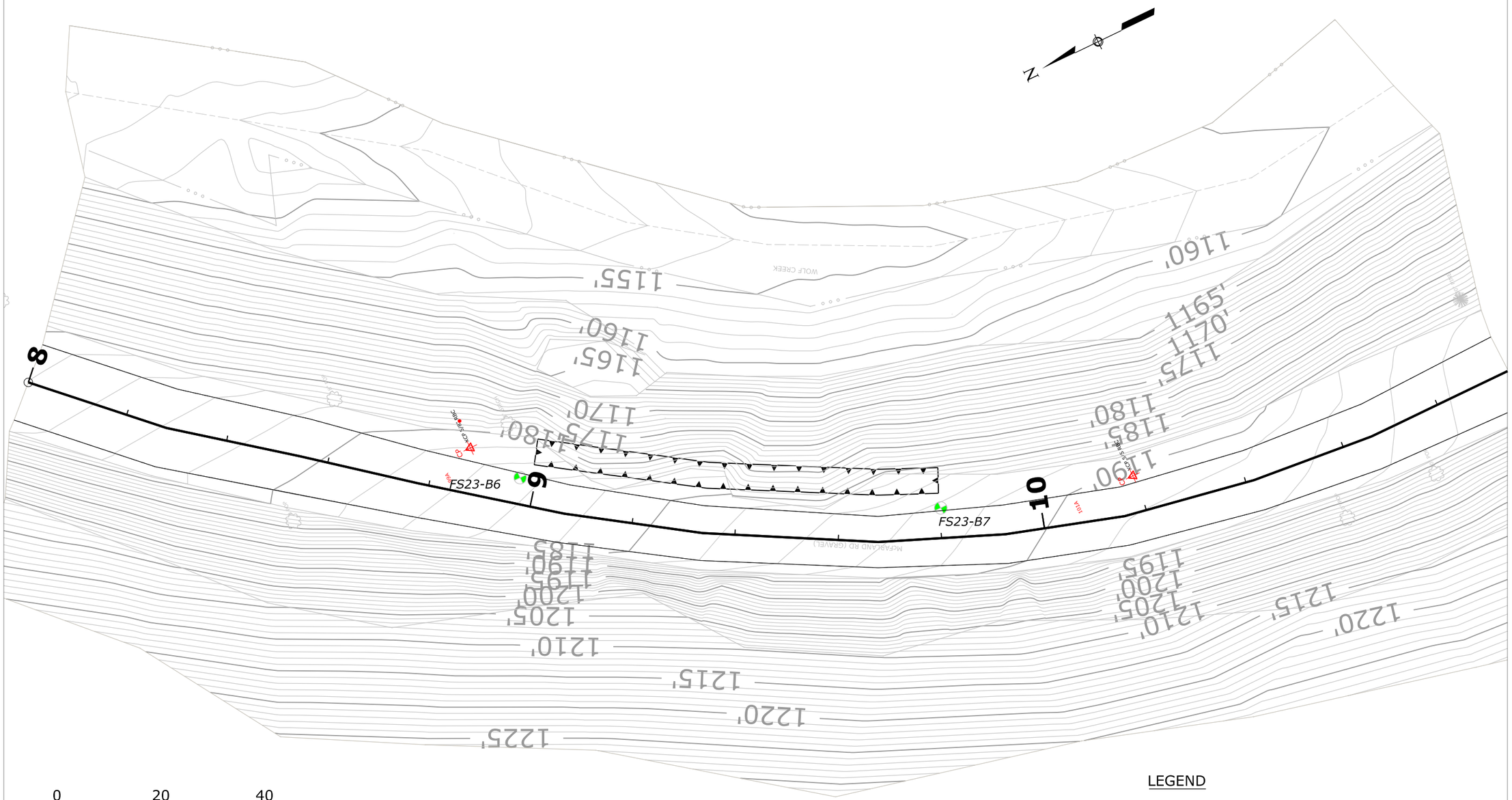
SCALE IN FEET

P 370 BL - PLAN
MILEPOST 10.189

c:\pwworking\jmt\d0867157\mHD_McFarland 2.dgn (P 370 BL - Plan)

13 May 2024 10:38 AM

STATE	PROJECT	SHEET NUMBER
		P 371 Plan



LEGEND

RETAINING WALL

BORING

P 371 BL - P 371 PLAN
MILEPOST 10.378

c:\pwworking\jmt\d0867157\mhD_McFarland 3.dgn [P 371 BL - P 371 Plan]
13 May 2024 10:41 AM

Appendix B

- Boring Log and Laboratory Testing Report

April 22, 2024

Johnson, Mirmiran & Thompson, Inc.
40 Wright Avenue
Hunt Valley, Maryland 21030

Attention: Mr. Vijaya Garimella, P.E., Ph. D., D. GE.

Reference: **Data from Geotechnical Exploration**
Task 24: FS – 23 McFarland Road
McFarland Road, Turtletown, Tennessee
S&ME Project No. 23430366

Dear Mr. Garimella,

The following presents the results of our geotechnical exploration and laboratory testing performed for the Task 24: FS-23 McFarland Road project in Turtletown, Tennessee. The work was performed in general accordance with S&ME Proposal No. 23430366 dated September 7, 2023 and as authorized by Mr. William Schaub with Johnson Mirmiran & Thompson, Inc. The purpose of the project was to characterize general subsurface conditions in the project area and provide laboratory test results for use in making geotechnical recommendations. The boring logs, laboratory tests results, and photographs are attached to this letter. Please let us know if you have any questions or if we may be of further assistance.

Sincerely,
S&ME, Inc.

Joshua A. Baines, EI
Geotechnical Operations Manager

Daniel R. Boles, PE
Principal Geotechnical Engineer

Attachments: Boring Logs
Laboratory Test Results
Site Photographs

Appendix B

- Boring Log and Laboratory Testing Report

PROJECT:	Task 24: FS - 23 McFarland Road Turtletown, Tennessee S&ME Project No. 23430366	BORING LOG: FS-23-B1 *Sheet 1 of 3*

DATE DRILLED: 01/24/2024	**ELEVATION:** 1050 ft	**NOTES:** Sample descriptions based on visual observations of obtained samples.
DRILL RIG: D-50	**DATUM:** NAVD88	
DRILLER: Frank Crane	**BORING DEPTH:** 50.6 ft	
HAMMER TYPE: Automatic hammer	**CLOSURE:** Cement Grout	
DRILLING METHOD: HQ CA, NQ	**LOGGED BY:** Pen Sibley	**NORTHING:** 308783.6 **EASTING:** 2449545.7
SAMPLING METHOD: SS, CORE	**PROJECT COORDINATE SYSTEM -** NAD 1983 StatePlane Tennessee FIPS 4100 Feet	

DEPTH (feet)	NOTES	Origin/Identifier	GRAPHIC	SAMPLE NO. (RECOVERY)	MATERIAL DESCRIPTION	BLOW COUNT DATA (SPT N-value)	STANDARD PENETRATION TEST DATA (△ % Fines, ○ NMC, ⊢⊣ PL---LL; 20 40 60 80 100)	ELEVATION
0	0.1	Residuum		SS-1	AGGREGATE BASE, 1 inch SILT (ML), little sand, firm to very stiff, blue gray with brown, relict structure, moist	7-11-8-6 N = 19		
				SS-2		4-4-3-2 N = 7		
5	4.0			SS-3	SILT (ML), little sand, stiff to hard, blue gray with brown, relict structure, moist	6-6-5-7 N = 11		1046
10				SS-4		17-15-10 N = 25		1041
15				SS-5		10-12-19 N = 31		1036
	15.5			SS-6	SILT (ML), little sand, little rock fragments, very stiff, blue gray with brown, relict structure, moist	14-11-17 N = 28		
20				SS-7		5-7-15 N = 22		1031

GROUNDWATER		DATE	DEPTH (FT)	REMARKS
ATD	▽	01/23/2024		Not encountered prior to coring
END OF DRILLING	▼			
AFTER DRILLING	▼	01/25/2024		Not encountered
AFTER DRILLING	▼			

GROUNDWATER DEPTHS ARE NOT EXACT AND MAY VARY SUBSTANTIALLY FROM THOSE INDICATED. ATD = AT TIME OF DRILLING
LL=Liquid Limit, PL = Plastic Limit, NMC = Natural Moisture Content, PPV = Pocket Penetrometer (tsf), PTV = Pocket Torvane (tsf), AR = Auger Refusal, IGM = Intermediate Geomaterial

PROJECT:	Task 24: FS - 23 McFarland Road Turtletown, Tennessee S&ME Project No. 23430366	BORING LOG: FS-23-B1 *Sheet 2 of 3*

DATE DRILLED: 01/24/2024	**ELEVATION:** 1050 ft	**NOTES:** Sample descriptions based on visual observations of obtained samples.
DRILL RIG: D-50	**DATUM:** NAVD88	
DRILLER: Frank Crane	**BORING DEPTH:** 50.6 ft	
HAMMER TYPE: Automatic hammer	**CLOSURE:** Cement Grout	
DRILLING METHOD: HQ CA, NQ	**LOGGED BY:** Pen Sibley	**NORTHING:** 308783.6 **EASTING:** 2449545.7
SAMPLING METHOD: SS, CORE	**PROJECT COORDINATE SYSTEM -** NAD 1983 StatePlane Tennessee FIPS 4100 Feet	

DEPTH (feet)	NOTES	Origin/Identifier	GRAPHIC	SAMPLE NO. (RECOVERY)	MATERIAL DESCRIPTION	BLOW COUNT DATA (SPT N-value)	STANDARD PENETRATION TEST DATA (△ % Fines, ○ NMC, ⊢⊣ PL---LL; 20 40 60 80 100)	ELEVATION
	22.0	Residuum			SILT (ML), little sand, little rock fragments, very stiff, yellow brown with brown, relict structure, moist			
				SS-8		7-9-11 N = 20		1026
25								
				SS-9		7-11-11 N = 22		1021
30								
	Casing Advancer Refusal at 35.2 feet			SS-10		9-11-13 N = 24		1016
35								
	35.2			Run-1 REC-8% RQD-0%	SLATE, gray, incompetent, very poor quality, highly weathered, moderately hard			
	35.6				SLATE, gray with yellow brown, incompetent, very poor quality, slightly weathered to highly weathered, moderately hard to hard			
				Run-2 REC-34% RQD-0%				1011
40								
				Run-3				

GROUNDWATER		DATE	DEPTH (FT)	REMARKS
ATD	▽	01/23/2024		Not encountered prior to coring
END OF DRILLING	▼			
AFTER DRILLING	▼	01/25/2024		Not encountered
AFTER DRILLING	▼			

GROUNDWATER DEPTHS ARE NOT EXACT AND MAY VARY SUBSTANTIALLY FROM THOSE INDICATED. ATD = AT TIME OF DRILLING
LL=Liquid Limit, PL = Plastic Limit, NMC = Natural Moisture Content, PPV = Pocket Penetrometer (tsf), PTV = Pocket Torvane (tsf),
AR = Auger Refusal, IGM = Intermediate Geomaterial

PROJECT:	Task 24: FS - 23 McFarland Road Turtletown, Tennessee S&ME Project No. 23430366	BORING LOG: FS-23-B1 *Sheet 3 of 3*

DATE DRILLED: 01/24/2024	**ELEVATION:** 1050 ft	**NOTES:** Sample descriptions based on visual observations of obtained samples.
DRILL RIG: D-50	**DATUM:** NAVD88	
DRILLER: Frank Crane	**BORING DEPTH:** 50.6 ft	
HAMMER TYPE: Automatic hammer	**CLOSURE:** Cement Grout	
DRILLING METHOD: HQ CA, NQ	**LOGGED BY:** Pen Sibley	**NORTHING:** 308783.6 **EASTING:** 2449545.7
SAMPLING METHOD: CORE, SS	**PROJECT COORDINATE SYSTEM -** NAD 1983 StatePlane Tennessee FIPS 4100 Feet	

DEPTH (feet)	NOTES	GRAPHIC	SAMPLE NO. (RECOVERY)	MATERIAL DESCRIPTION	ELEVATION
45	45.6		REC-32% RQD-0%	SLATE, gray with yellow brown, incompetent, very poor quality, slightly weathered to highly weathered, moderately hard to hard	
	Hole Cave at 46.6 feet			SLATE, gray with yellow brown, fairly continuous, very poor quality, slightly weathered to highly weathered, moderately hard to hard	
			Run-4 REC-80% RQD-16%		1001
50	50.6			Borehole terminated at 50.6 feet	
					996
55					
					991
60					
					986
65					

GROUND WATER		DATE/TIME	DEPTH (FT)	REMARKS
ATD	▽	01/23/2024		Not encountered prior to coring
END OF DRILLING	▼			
AFTER DRILLING	▼	01/25/2024		Not encountered
AFTER DRILLING	▼			

GROUNDWATER DEPTHS ARE NOT EXACT AND MAY VARY SUBSTANTIALLY FROM THOSE INDICATED. ATD = AT TIME OF DRILLING

Project:	**Task 24: FS - 23 McFarland Road** **Turtletown, Tennessee** 23430366	**Location Photos:**	**FS-23-B1**
		Sheet 1 of 1	
Date: 01/24/2024	**Elevation:** 1050 ft	Notes:	
Photograhed by: Pen Sibley	Northing: 308783.6 Easting: 2449545.7		

Box 1 of 1: 35.2' to 50.2'

PROJECT:	Task 24: FS - 23 McFarland Road Turtletown, Tennessee S&ME Project No. 23430366	BORING LOG: FS-23-B2 *Sheet 1 of 1*

DATE DRILLED: 01/24/2024	**ELEVATION:** 1047 ft	**NOTES:** Sample descriptions based on visual observations of obtained samples.
DRILL RIG: D-50	**DATUM:** NAVD88	
DRILLER: Frank Crane	**BORING DEPTH:** 20.5 ft	
HAMMER TYPE: Automatic hammer	**CLOSURE:** Cement Grout	
DRILLING METHOD: HQ CA, NQ	**LOGGED BY:** Pen Sibley	**NORTHING:** 308829.0 **EASTING:** 2449617.5
SAMPLING METHOD: SS, CORE	**PROJECT COORDINATE SYSTEM -** NAD 1983 StatePlane Tennessee FIPS 4100 Feet	

DEPTH (feet)	NOTES	Origin/Identifier	GRAPHIC	SAMPLE NO. (RECOVERY)	MATERIAL DESCRIPTION	BLOW COUNT DATA (SPT N-value)	STANDARD PENETRATION TEST DATA (△ % Fines, ○ NMC, ⊢⊣ PL---LL; 20 40 60 80 100)	ELEVATION
0	0.1	Residuum		SS-1	AGGREGATE BASE, 1 inch SILT (ML), little sand, little rock fragments, stiff to very stiff, blue gray with brown, relict structure, moist	8-10-12-14 N = 22		
				SS-2		9-6-4-5 N = 10		
5	Casing Advancer Refusal at 6.0 feet 4.0			SS-3	SILTY SAND WITH GRAVEL (SM), little sand, little rock fragments, stiff to very stiff, blue gray with brown, relict structure, moist	9-16-14-19 N = 30		1042
	6.0			Run-1 REC-51% RQD-9%	SLATE, gray with yellow brown, competent, very poor quality, slightly weathered to highly weathered, moderately hard			
10	10.5			Run-2 REC-42% RQD-0%	SLATE, gray with yellow brown, competent, very poor quality, highly weathered to completely weathered, soft			1037
15	15.5			Run-3 REC-52% RQD-12%	SLATE, gray with yellow brown, competent, very poor quality, slightly weathered to highly weathered, moderately hard			1032
20	Hole Cave at 17.4 feet 20.5				Borehole terminated at 20.5 feet			1027

GROUNDWATER		DATE	DEPTH (FT)	REMARKS
ATD	▽	01/23/2024		Not encountered prior to coring
END OF DRILLING	▼			
AFTER DRILLING	▼	01/25/2024		Not encountered
AFTER DRILLING	▼			

GROUNDWATER DEPTHS ARE NOT EXACT AND MAY VARY SUBSTANTIALLY FROM THOSE INDICATED. ATD = AT TIME OF DRILLING
LL=Liquid Limit, PL = Plastic Limit, NMC = Natural Moisture Content, PPV = Pocket Penetrometer (tsf), PTV = Pocket Torvane (tsf),
AR = Auger Refusal, IGM = Intermediate Geomaterial

Project:	**Task 24: FS - 23 McFarland Road** **Turtletown, Tennessee** 23430366	**Location Photos:**	**FS-23-B2**
		Sheet 1 of 1	
Date: 01/24/2024	**Elevation:** 1047 ft	Notes:	
Photograhed by: Pen Sibley	Northing: 308829.0	Easting: 2449617.5	

Box 1 of 1: 6.0' to 20.5'

PROJECT:	Task 24: FS - 23 McFarland Road Turtletown, Tennessee S&ME Project No. 23430366	BORING LOG: FS-23-B3 *Sheet 1 of 1*

DATE DRILLED: 01/24/2024	**ELEVATION:** 1143 ft	**NOTES:** Sample descriptions based on visual observations of obtained samples.
DRILL RIG: D-50	**DATUM:** NAVD88	
DRILLER: Frank Crane	**BORING DEPTH:** 15.3 ft	
HAMMER TYPE: Automatic hammer	**CLOSURE:** Cement Grout	
DRILLING METHOD: HQ CA, NQ	**LOGGED BY:** Pen Sibley	**NORTHING:** 307897.5 **EASTING:** 2451910.2
SAMPLING METHOD: SS, CORE	**PROJECT COORDINATE SYSTEM -** NAD 1983 StatePlane Tennessee FIPS 4100 Feet	

DEPTH (feet)	NOTES	Origin/Identifier	GRAPHIC	SAMPLE NO. (RECOVERY)	MATERIAL DESCRIPTION	BLOW COUNT DATA (SPT N-value)	STANDARD PENETRATION TEST DATA (△ % Fines, ○ NMC, ⊢⊣ PL---LL; 20 40 60 80 100)	ELEVATION
0								
	0.1	Residuum		SS-1	AGGREGATE BASE, 1 inch SILTY, CLAYEY SAND WITH GRAVEL (SC-SM), loose, gray, fine to medium grained, wet	5-6-3-5 N = 9		
	2.0			SS-2	SILTY, CLAYEY SAND WITH GRAVEL (SC-SM), loose to very dense, orange brown with gray, fine to medium grained, moist	3-3-2-3 N = 5		
5	Hole Cave at 3.2 feet Casing Advancer Refusal at 5.6 feet			SS-3		3-5-50/3" N = 50/3"		1138
	5.6				GRAYWACKE, blue gray, competent to fairly continuous, very poor quality to fair quality, medium grained to coarse grained, fresh to moderately weathered, very hard			
	7.2			Run-1 REC-43% RQD-23%	Void			1133
10	9.9				GRAYWACKE, blue gray, continuous, good quality, medium grained to coarse, slightly weathered to fresh, very hard			
				Run-2 REC-90% RQD-52%				1128
15	15.3				Borehole terminated at 15.3 feet			
20								1123

GROUNDWATER		DATE	DEPTH (FT)	REMARKS
ATD	▽	01/23/2024		Not encountered prior to coring
END OF DRILLING	▼			
AFTER DRILLING	▼	01/25/2024		Rain water running into boring
AFTER DRILLING	▼			

GROUNDWATER DEPTHS ARE NOT EXACT AND MAY VARY SUBSTANTIALLY FROM THOSE INDICATED. ATD = AT TIME OF DRILLING
LL=Liquid Limit, PL = Plastic Limit, NMC = Natural Moisture Content, PPV = Pocket Penetrometer (tsf), PTV = Pocket Torvane (tsf), AR = Auger Refusal, IGM = Intermediate Geomaterial

Project:	Task 24: FS - 23 McFarland Road Turtletown, Tennessee 23430366			Location Photos:	FS-23-B3
				Sheet 1 of 1	
Date:	01/24/2024	Elevation:	1143 ft	Notes:	
Photograhed by:	Pen Sibley	Northing: 307897.5	Easting: 2451910.2		

Box 1 of 1: 5.6' to 15.3'

PROJECT:	Task 24: FS - 23 McFarland Road Turtletown, Tennessee S&ME Project No. 23430366	BORING LOG: FS-23-B4 *Sheet 1 of 1*

DATE DRILLED: 01/23/2024	**ELEVATION:** 1144 ft	**NOTES:** Sample descriptions based on visual observations of obtained samples.
DRILL RIG: D-50	**DATUM:** NAVD88	
DRILLER: Frank Crane	**BORING DEPTH:** 10.5 ft	
HAMMER TYPE: Automatic hammer	**CLOSURE:** Cement Grout	
DRILLING METHOD: HQ CA, NQ	**LOGGED BY:** Pen Sibley	**NORTHING:** 307962.9 **EASTING:** 2451837.5
SAMPLING METHOD: SS, CORE	**PROJECT COORDINATE SYSTEM -** NAD 1983 StatePlane Tennessee FIPS 4100 Feet	

DEPTH (feet)	NOTES	Origin/Identifier	GRAPHIC	SAMPLE NO. (RECOVERY)	MATERIAL DESCRIPTION	BLOW COUNT DATA (SPT N-value)	STANDARD PENETRATION TEST DATA (△ % Fines, ○ NMC, ⊢⊣ PL---LL; 20 40 60 80 100)	ELEVATION
0	Casing Advancer	Residuum		SS-1	PWR, sampled as POORLY GRADED	30-50/3" N = 50/3"		
	Refusal at 0.9 feet	0.9			GRAVEL WITH SAND (GP), very dense, gray, fine to medium grained, moist			
				Run-1 REC-100% RQD-59%	GRAYWACKE, blue gray, continuous, fair quality, medium grained to coarse, fresh, very hard			
5		5.5						1139
				Run-2 REC-98% RQD-88%	GRAYWACKE, blue gray, continuous, good quality, medium grained, slightly weathered to fresh, very hard			
	Hole Cave at 9.7 feet							
10		10.5						1134
					Borehole terminated at 10.5 feet			
15								1129
20								1124

GROUNDWATER		DATE	DEPTH (FT)	REMARKS
ATD	▽	01/23/2024		Not encountered prior to coring
END OF DRILLING	▼			
AFTER DRILLING	▼	01/25/2024	1.3	
AFTER DRILLING	▼			

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AR = Auger Refusal, IGM = Intermediate Geomaterial

Project:	Task 24: FS - 23 McFarland Road Turtletown, Tennessee 23430366			Location Photos:	FS-23-B4
				Sheet 1 of 2	
Date:	01/23/2024	Elevation:	1144 ft	Notes:	
Photograhed by:	Pen Sibley	Northing: 307962.9	Easting: 2451837.5		

Box 1 of 2: 0.9' to 5.5'

Project:	Task 24: FS - 23 McFarland Road Turtletown, Tennessee 23430366			Location Photos:	FS-23-B4
				Sheet 2 of 2	
Date:	01/23/2024	Elevation:	1144 ft	Notes:	
Photograhed by:	Pen Sibley	Northing:	307962.9	Easting:	2451837.5

Box 2 of 2: 5.5' to 10.5'

PROJECT:	Task 24: FS - 23 McFarland Road Turtletown, Tennessee S&ME Project No. 23430366	BORING LOG: FS-23-B5 *Sheet 1 of 1*

DATE DRILLED: 01/23/2024	**ELEVATION:** 1145 ft	**NOTES:** Sample descriptions based on visual observations of obtained samples.
DRILL RIG: D-50	**DATUM:** NAVD88	
DRILLER: Frank Crane	**BORING DEPTH:** 14.0 ft	
HAMMER TYPE: Automatic hammer	**CLOSURE:** Cement Grout	
DRILLING METHOD: HQ CA, NQ	**LOGGED BY:** Pen Sibley	**NORTHING:** 308077.0 **EASTING:** 2451831.6
SAMPLING METHOD: SS, CORE	**PROJECT COORDINATE SYSTEM -** NAD 1983 StatePlane Tennessee FIPS 4100 Feet	

DEPTH (feet)	NOTES	Origin/Identifier	GRAPHIC	SAMPLE NO. (RECOVERY)	MATERIAL DESCRIPTION	BLOW COUNT DATA (SPT N-value)	STANDARD PENETRATION TEST DATA (△ % Fines, ○ NMC, ⊢⊣ PL---LL; 20 40 60 80 100)	ELEVATION
0					AGGREGATE BASE, 2 inches			
	0.2	Residuum			POORLY GRADED GRAVEL WITH SAND (GP), little clay, medium dense, gray, fine to medium grained, moist	5-15-7-5 N = 22		
	Casing Advancer Refusal at 3.0 feet			SS-1				
	3.0				SLATE, gray with yellow brown, continuous, very poor quality, slightly weathered, moderately hard			
				Run-1 REC-96% RQD-0%				
5								1140
	6.3				GRAYWACKE, blue gray, continuous to competent, good quality, coarse grained, fresh, very hard			
	Loss of circulation			Run-2 REC-100% RQD-76%				
10								1135
	Hole Cave at 11.4 feet			Run-3 REC-40% RQD-40%				
	14.0				Borehole terminated at 14.0 feet			
15								1130
20								1125

GROUNDWATER		DATE	DEPTH (FT)	REMARKS
ATD	▽	01/23/2024		Not encountered prior to coring
END OF DRILLING	▼			
AFTER DRILLING	▼	01/24/2024	6.0	
AFTER DRILLING	▼			

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Project:	Task 24: FS - 23 McFarland Road Turtletown, Tennessee 23430366			Location Photos:	FS-23-B5
				Sheet 1 of 1	
Date:	01/23/2024	Elevation:	1145 ft	Notes:	
Photograhed by:	Pen Sibley	Northing: 308077.0	Easting: 2451831.6		

Box 1 of 1: 3.0' to 14.0'

PROJECT:	Task 24: FS - 23 McFarland Road Turtletown, Tennessee S&ME Project No. 23430366	BORING LOG: FS-23-B6 *Sheet 1 of 1*

DATE DRILLED: 01/23/2024	**ELEVATION:** 1183 ft	**NOTES:** Sample descriptions based on visual observations of obtained samples.
DRILL RIG: D-50	**DATUM:** NAVD88	
DRILLER: Frank Crane	**BORING DEPTH:** 16.6 ft	
HAMMER TYPE: Automatic hammer	**CLOSURE:** Cement Grout	
DRILLING METHOD: HQ CA, NQ	**LOGGED BY:** Pen Sibley	**NORTHING:** 307163.2 **EASTING:** 2452324.8
SAMPLING METHOD: CORE, SS	**PROJECT COORDINATE SYSTEM -** NAD 1983 StatePlane Tennessee FIPS 4100 Feet	

DEPTH (feet)	NOTES	Origin/Identifier	GRAPHIC	SAMPLE NO. (RECOVERY)	MATERIAL DESCRIPTION	BLOW COUNT DATA (SPT N-value)	STANDARD PENETRATION TEST DATA (△ % Fines, ○ NMC, ⊢⊣ PL---LL; 20 40 60 80 100)	ELEVATION
0	Casing Advancer Refusal at 1.7 feet	Residuum		SS-1	AGGREGATE BASE, 1 inch PWR, sampled as CLAYEY SAND WITH GRAVEL (SC), little clay, medium dense, brown to gray, fine to medium grained, moist	10-11-16-50/3" N = 27		
0.1								
1.7				Run-1 REC-96% RQD-26%	SLATE, blue gray, continuous, poor quality to excellent quality, moderately weathered to fresh, hard			
5	Hole Cave at 6.1 feet			Run-2 REC-90% RQD-70%				1178
10				Run-3 REC-100% RQD-90%				1173
15				Run-4 REC-100% RQD-100%				1168
16.6					Borehole terminated at 16.6 feet			
20								1163

GROUNDWATER		DATE	DEPTH (FT)	REMARKS
ATD	▽	01/23/2024		Not encountered prior to coring
END OF DRILLING	▼			
AFTER DRILLING	▼	01/24/2024	4.5	
AFTER DRILLING	▼			

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Project:	Task 24: FS - 23 McFarland Road Turtletown, Tennessee 23430366			Location Photos:	FS-23-B6
				Sheet 1 of 2	
Date:	01/23/2024	Elevation:	1183 ft	Notes:	
Photograhed by:	Pen Sibley	Northing: 307163.2	Easting: 2452324.8		

Box 1 of 2: 1.7' to 8.6'

Project:	**Task 24: FS - 23 McFarland Road** **Turtletown, Tennessee** 23430366	**Location Photos:**	**FS-23-B6**
		Sheet 2 of 2	
Date: 01/23/2024	**Elevation:** 1183 ft	Notes:	
Photograhed by: Pen Sibley	Northing: 307163.2 Easting: 2452324.8		

Box 2 of 2: 8.6' to 16.6'

PROJECT:	Task 24: FS - 23 McFarland Road Turtletown, Tennessee S&ME Project No. 23430366	BORING LOG: FS-23-B7 *Sheet 1 of 1*

DATE DRILLED: 01/23/2024	**ELEVATION:** 1188 ft	**NOTES:** Sample descriptions based on visual observations of obtained samples.
DRILL RIG: D-50	**DATUM:** NAVD88	
DRILLER: Frank Crane	**BORING DEPTH:** 12.4 ft	
HAMMER TYPE: Automatic hammer	**CLOSURE:** Cement Grout	
DRILLING METHOD: HQ CA, NQ	**LOGGED BY:** Pen Sibley	**NORTHING:** 307092.5 **EASTING:** 2452284.3
SAMPLING METHOD: CORE, SS	**PROJECT COORDINATE SYSTEM -** NAD 1983 StatePlane Tennessee FIPS 4100 Feet	

DEPTH (feet)	NOTES	Origin/Identifier	GRAPHIC	SAMPLE NO. (RECOVERY)	MATERIAL DESCRIPTION	BLOW COUNT DATA (SPT N-value)	STANDARD PENETRATION TEST DATA (△ % Fines, ○ NMC, ⊢⊣ PL---LL; 20 40 60 80 100)	ELEVATION
0	0.1 Casing Advancer Refusal at 3.0 feet	Residuum		SS-1	TOPSOIL, 1 inch POORLY GRADED SAND WITH GRAVEL (SP), little clay, medium dense to very dense, brown, fine to medium grained, moist	7-11-12-10 N = 23		
	3.0				SLATE, blue gray, fairly continuous to continuous, fair quality to excellent quality, slightly weathered to fresh, hard			
5				Run-1 REC-83% RQD-76%				1184
				Run-2 REC-100% RQD-90%				
10	Hole Cave at 10.7 feet							1179
	12.4			Run-3 REC-92% RQD-92%	Borehole terminated at 12.4 feet			
15								1174
20								1169

GROUNDWATER		DATE	DEPTH (FT)	REMARKS
ATD	▽	01/23/2024		Not encountered prior to coring
END OF DRILLING	▼			
AFTER DRILLING	▼	01/24/2024	3.0	
AFTER DRILLING	▼			

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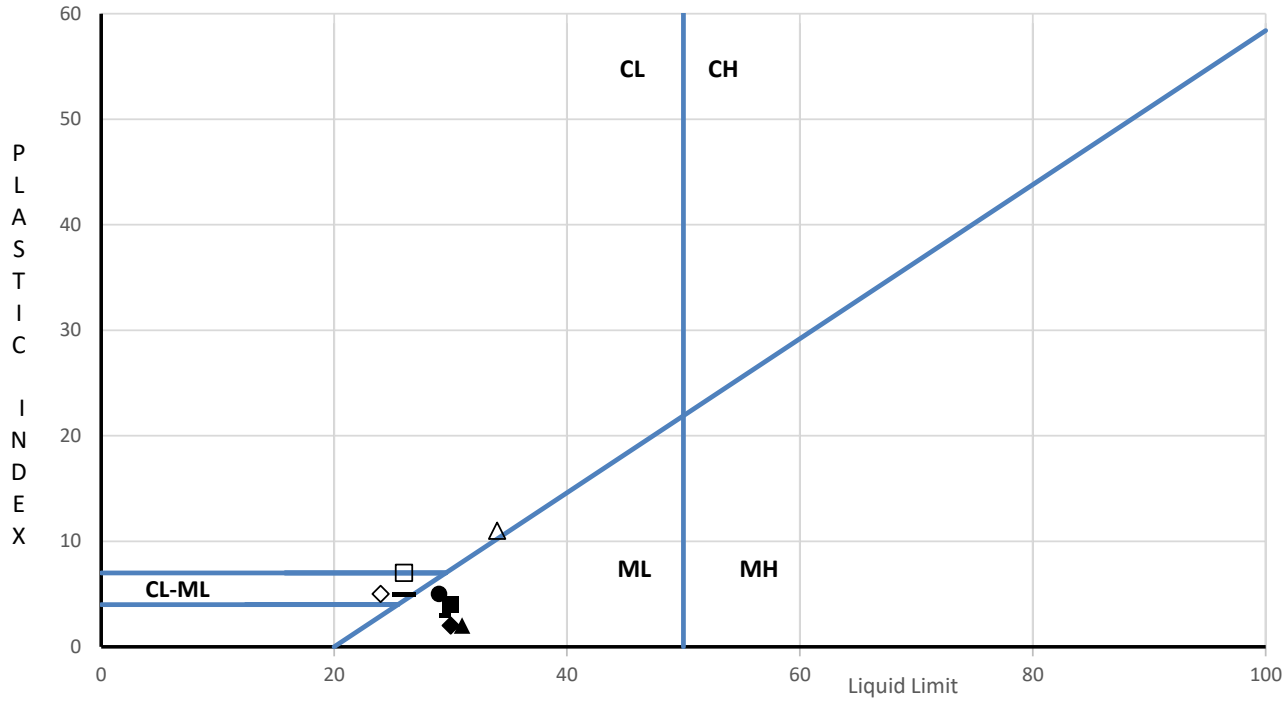
Project:	Task 24: FS - 23 McFarland Road Turtletown, Tennessee 23430366			Location Photos:	FS-23-B7
				Sheet 1 of 1	
Date:	01/23/2024	Elevation:	1188 ft	Notes:	
Photograhed by:	Pen Sibley	Northing: 307092.5	Easting: 2452284.3		

Box 1 of 1: 3.0' to 12.4'



Specimen Identification				MC	LL	PL	PI	Fines	Classification (symbol is based on minus 40 material only when no grain size information is present.)	
	ID	No.	Top Depth						Symbol	Name
■	FS-23-B1	SS-2	2	20.4	30	26	4	58.0	ML	SANDY SILT WITH GRAVEL (A-4, 1)
◆	FS-23-B1	SS-4	8.5	8.3	30	28	2	56.9	ML	SANDY SILT (A-4, 0)
▲	FS-23-B1	SS-7	18.5	8.0	31	29	2	64.7	ML	SANDY SILT (A-4, 1)
●	FS-23-B2	SS-2	2	19.8	29	24	5	66.8	ML	SANDY SILT (A-4, 2)
▬	FS-23-B2	SS-3	4	4.1	29	26	3	35.6	SM	SILTY SAND WITH GRAVEL (A-4, 0)
▬	FS-23-B3	SS-1	0	14.8	26	21	5	28.3	SC-SM	SILTY, CLAYEY SAND WITH GRAVEL (A-2-4, 0)
□	FS-23-B3	SS-2	2	20.8	26	19	7	26.9	SC-SM	SILTY, CLAYEY SAND WITH GRAVEL (A-2-4, 0)
◇	FS-23-B3	SS-3	4	5.2	24	19	5	21.0	SC-SM	SILTY, CLAYEY SAND WITH GRAVEL (A-1-b, 0)
△	FS-23-B6	SS-1	0	3.5	34	23	11	24.7	SC	CLAYEY SAND WITH GRAVEL (A-2-6, 0)

INDEX TEST RESULTS

Project Name	Task 24: FS - 23 McFarland Road
Project Number	23430366
Approved by	Date
	2/29/2024 10:28

Report No. CHAT_24001009
Report Date 2/29/2024

AASHTO T265: Standard Method of Test for Laboratory Determination of Moisture Content of Soils	Form Number	KL-D2216-19
	Form Revision	1
	Test Date	2/20/2024
	Sample Date	1/23/2024

Project Number	23430366
Project Name	Task 24: FS - 23 McFarland Road
Client Name	Johnson, Mirmiran & Thopson, Inc.
Client Address	40 Wright Avenue, Hunt Valley, Maryland 21030

Method: **A (1%)** ☐ **B (0.1%)** ☒

Balance ID. 22533-CL Calibration Date: 8/29/2023

Oven ID. 22617 Calibration Date: 9/25/2023

Boring No.	Sample ID	Top Depth	Tare #	Tare Weight	Tare Wt.+ Wet Wt	Tare Wt. + Dry Wt	Water Weight	Percent Moisture	Note
		ft		grams	grams	grams	grams	%	
FS-23-B1	SS-2	2.00	142	95.52	200.40	182.62	17.78	20.4	
FS-23-B1	SS-4	8.50	130	98.05	199.37	191.63	7.74	8.3	
FS-23-B1	SS-7	18.50	135	97.15	204.86	196.84	8.02	8.0	
FS-23-B2	SS-2	2.00	141	96.05	142.18	134.54	7.64	19.8	
FS-23-B2	SS-3	4.00	137	97.48	154.72	152.49	2.23	4.1	1
FS-23-B3	SS-1	0.00	109	203.29	223.99	221.32	2.67	14.8	1
FS-23-B3	SS-2	2.00	120	195.64	220.21	215.98	4.23	20.8	1
FS-23-B3	SS-3	4.00	102	199.14	247.45	245.06	2.39	5.2	1
FS-23-B6	SS-1	0.00	113	200.45	242.58	241.16	1.42	3.5	1

References / Comments / Deviations:

1 - Did not meet minimum mass requirements

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TThompson — *Tested by*

TThompson — *Approved by*

Signature

Chattanooga

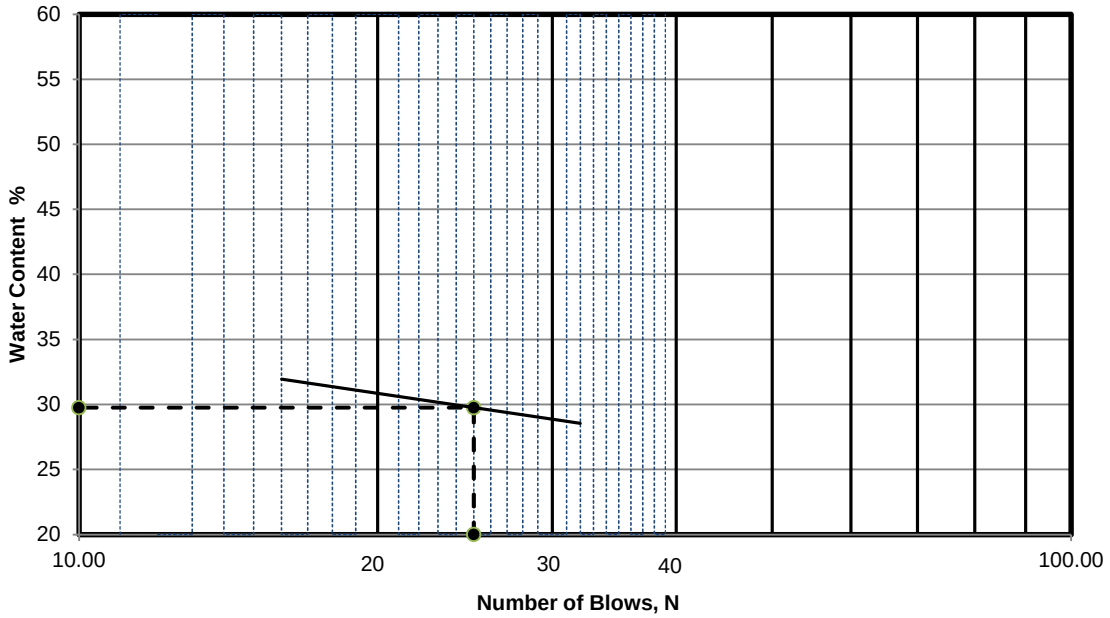
4291 Highway 58, Suite 101, Chattanooga, TN 37416

	AASHTO T89-T90: Standard Method of Test for Liquid Limit, Plastic Limit, and Plasticity Index of Soil	Form Number	**KL-D4318-17**
		Form Revision	**1**
		Test Date	2/26/2024
		Sample Date	1/23/2024

Project Number	23430366		
Project Name	Task 24: FS - 23 McFarland Road		
Client Name	Johnson, Mirmiran & Thopson, Inc.		
Client Address	40 Wright Avenue, Hunt Valley, Maryland 21030		
KeyLAB ID	81-865	Sample Type	SS
Location ID	FS-23-B1	Sample Top Depth	2
		Sample Base Depth	4
Description	Light Brown, SANDY SILT WITH GRAVEL (ML), (A-4,1)	Test Method	Multipoint

Type and Specification	*S&ME ID #*	*Cal Date:*	*Type and Specification*	*S&ME ID #*	*Cal Date:*
Balance (0.01 g)	22533-CL	8/29/2023	Grooving tool	34230	2/20/2024
LL Apparatus	22693	2/20/2024			
Oven	22617	9/25/2023			

		Liquid Limit						Plastic Limit		
	Tare #:	44	43	65				5		
A	Tare Weight	13.65	13.67	13.78				81.62		
B	Wet Soil Weight + A	28.57	25.82	26.63				91.80		
C	Dry Soil Weight + A	25.26	23.07	23.52				89.70		
D	Water Weight (B-C)	3.31	2.75	3.11				2.10		
E	Dry Soil Weight (C-A)	11.61	9.40	9.74				8.08		
F	% Moisture (D/E)*100	28.5	29.3	31.9				26.0		
N	# OF DROPS	32	28	16				**26.0**		



Sample Preparation:

- ○ in natural condition
- ◉ dry prep
- ○ wet prep

Liquid Limit	**30**
Plastic Limit	**26**
Plastic Index	**4**
ASTM	**ML**

References / Comments / Deviations:

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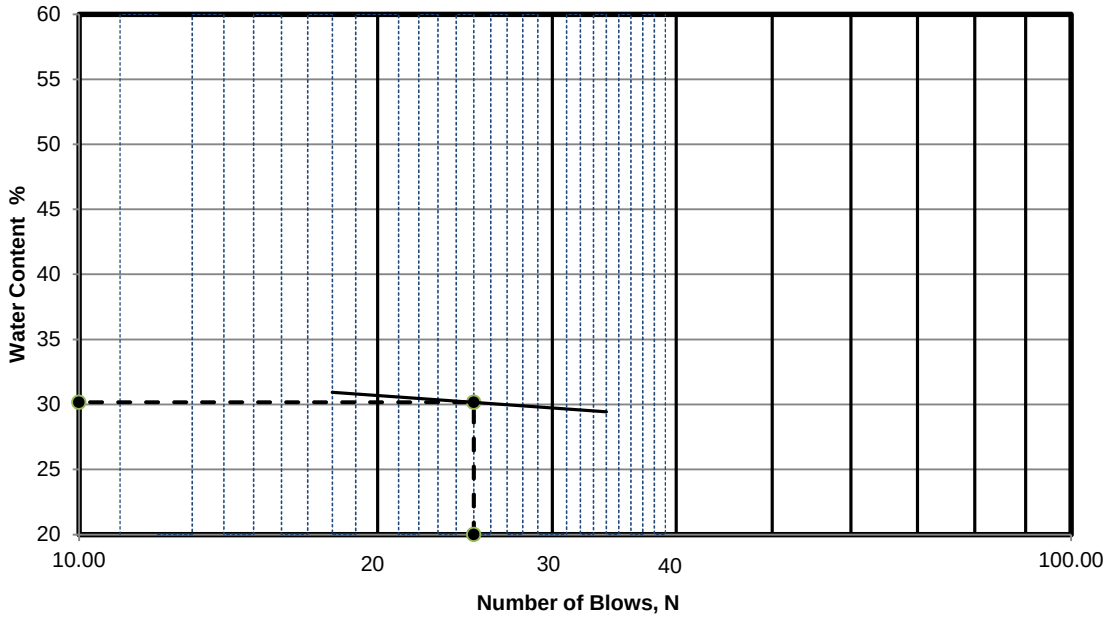
Chattanooga	*4291 Highway 58, Suite 101, Chattanooga, TN 37416*	

	AASHTO T89-T90: Standard Method of Test for Liquid Limit, Plastic Limit, and Plasticity Index of Soil	Form Number	**KL-D4318-17**
		Form Revision	**1**
		Test Date	2/26/2024
		Sample Date	1/23/2024

Project Number	23430366		
Project Name	Task 24: FS - 23 McFarland Road		
Client Name	Johnson, Mirmiran & Thopson, Inc.		
Client Address	40 Wright Avenue, Hunt Valley, Maryland 21030		
KeyLAB ID	81-865	Sample Type	SS
Location ID	FS-23-B1	Sample Top Depth	8.5
		Sample Base Depth	10
Description	Gray, SANDY SILT (ML), (A-4,0)	Test Method	Multipoint

Type and Specification	*S&ME ID #*	*Cal Date:*	*Type and Specification*	*S&ME ID #*	*Cal Date:*
Balance (0.01 g)	22533-CL	8/29/2023	Grooving tool	34230	2/20/2024
LL Apparatus	22693	2/20/2024			
Oven	22617	9/25/2023			

		Liquid Limit						Plastic Limit		
	Tare #:	66	46	34				13		
A	Tare Weight	13.62	13.76	13.71				81.69		
B	Wet Soil Weight + A	26.25	27.34	26.46				91.71		
C	Dry Soil Weight + A	23.39	24.22	23.44				89.51		
D	Water Weight (B-C)	2.86	3.12	3.02				2.20		
E	Dry Soil Weight (C-A)	9.77	10.46	9.73				7.82		
F	% Moisture (D/E)*100	29.3	29.8	31.0				28.1		
N	# OF DROPS	30	34	18				**28.1**		



Sample Preparation:

- ○ in natural condition
- ◉ dry prep
- ○ wet prep

Liquid Limit	**30**
Plastic Limit	**28**
Plastic Index	**2**
ASTM	**ML**

References / Comments / Deviations:

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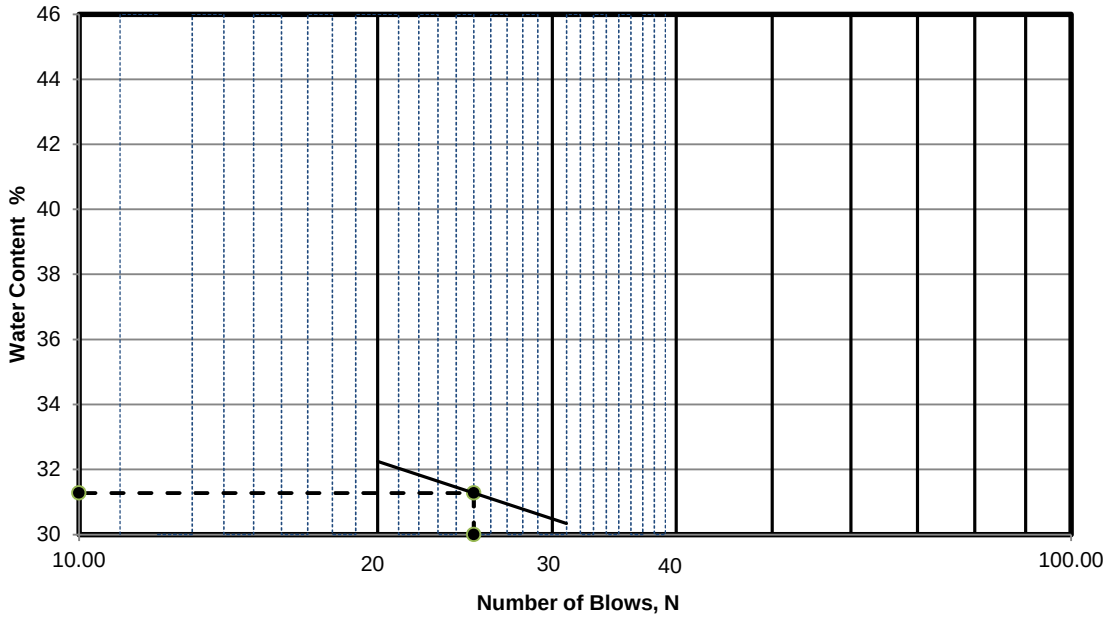
MCline	TThompson	
Tested by	*Approved by*	*Signature*
Chattanooga	*4291 Highway 58, Suite 101, Chattanooga, TN 37416*	

	AASHTO T89-T90: Standard Method of Test for Liquid Limit, Plastic Limit, and Plasticity Index of Soil	Form Number	**KL-D4318-17**
		Form Revision	**1**
		Test Date	2/27/2024
		Sample Date	1/23/2024

Project Number	23430366		
Project Name	Task 24: FS - 23 McFarland Road		
Client Name	Johnson, Mirmiran & Thopson, Inc.		
Client Address	40 Wright Avenue, Hunt Valley, Maryland 21030		
KeyLAB ID	81-865	Sample Type	SS
Location ID	FS-23-B1	Sample Top Depth	18.5
		Sample Base Depth	20
Description	Olive Brown, SANDY SILT (ML), (A-4,1)	Test Method	Multipoint

Type and Specification	*S&ME ID #*	*Cal Date:*	*Type and Specification*	*S&ME ID #*	*Cal Date:*
Balance (0.01 g)	22533-CL	8/29/2023	Grooving tool	34230	2/20/2024
LL Apparatus	22693	2/20/2024			
Oven	22617	9/25/2023			

		Liquid Limit						Plastic Limit		
	Tare #:	32	65	34				8		
A	Tare Weight	13.75	13.78	13.71				80.25		
B	Wet Soil Weight + A	25.89	27.09	26.41				91.04		
C	Dry Soil Weight + A	23.06	23.94	23.31				88.64		
D	Water Weight (B-C)	2.83	3.15	3.10				2.40		
E	Dry Soil Weight (C-A)	9.31	10.16	9.60				8.39		
F	% Moisture (D/E)*100	30.4	31.0	32.3				28.6		
N	# OF DROPS	31	26	20				**28.6**		



Sample Preparation:

- ○ in natural condition
- ○ dry prep
- ○ wet prep

Liquid Limit	**31**
Plastic Limit	**29**
Plastic Index	**2**
ASTM	**ML**

References / Comments / Deviations:

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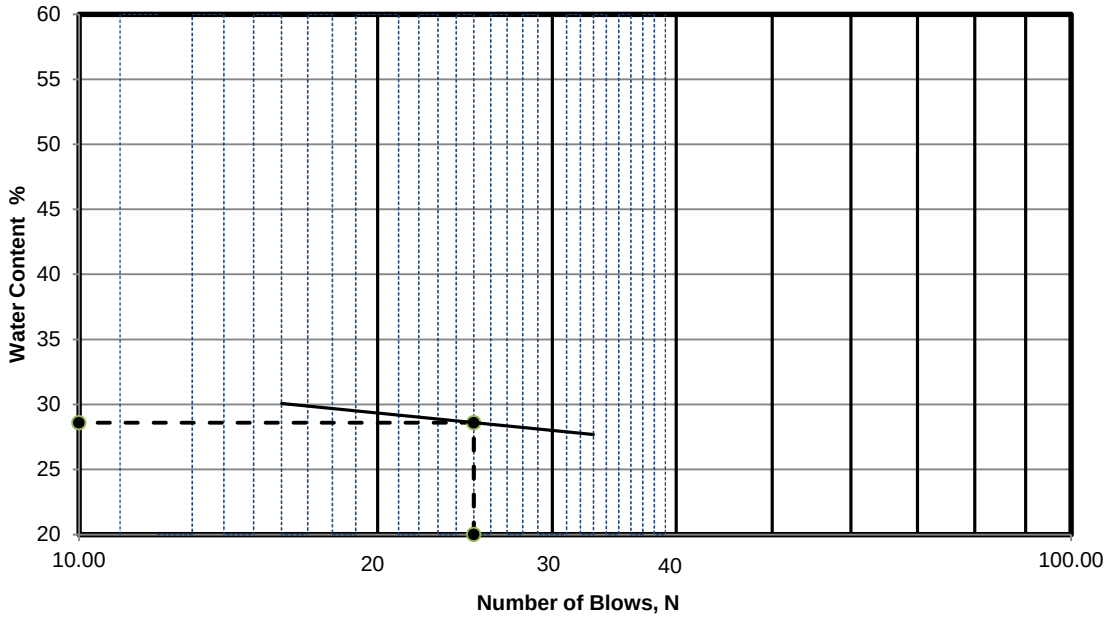
Chattanooga	*4291 Highway 58, Suite 101, Chattanooga, TN 37416*	

	AASHTO T89-T90: Standard Method of Test for Liquid Limit, Plastic Limit, and Plasticity Index of Soil	Form Number	**KL-D4318-17**
		Form Revision	**1**
		Test Date	2/26/2024
		Sample Date	1/23/2024

Project Number	23430366		
Project Name	Task 24: FS - 23 McFarland Road		
Client Name	Johnson, Mirmiran & Thopson, Inc.		
Client Address	40 Wright Avenue, Hunt Valley, Maryland 21030		
KeyLAB ID	81-865	Sample Type	SS
Location ID	FS-23-B2	Sample Top Depth	2
		Sample Base Depth	4
Description	Olive Brown, SANDY SILT (ML), (A-4, 2)	Test Method	Multipoint

Type and Specification	*S&ME ID #*	*Cal Date:*	*Type and Specification*	*S&ME ID #*	*Cal Date:*
Balance (0.01 g)	22533-CL	8/29/2023	Grooving tool	34230	2/20/2024
LL Apparatus	22693	2/20/2024			
Oven	22617	9/25/2023			

		Liquid Limit						Plastic Limit		
	Tare #:	35	71	32	68			3		
A	Tare Weight	13.61	13.64	13.75	13.78			80.25		
B	Wet Soil Weight + A	25.97	24.37	25.37	24.84			91.41		
C	Dry Soil Weight + A	23.33	21.98	22.67	22.33			89.26		
D	Water Weight (B-C)	2.64	2.39	2.70	2.51			2.15		
E	Dry Soil Weight (C-A)	9.72	8.34	8.92	8.55			9.01		
F	% Moisture (D/E)*100	27.2	28.7	30.3	29.4			23.9		
N	# OF DROPS	33	30	16	18			**23.9**		



Sample Preparation:

- ○ in natural condition
- ○ dry prep
- ○ wet prep

Liquid Limit	**29**
Plastic Limit	**24**
Plastic Index	**5**
ASTM	**ML**

References / Comments / Deviations:

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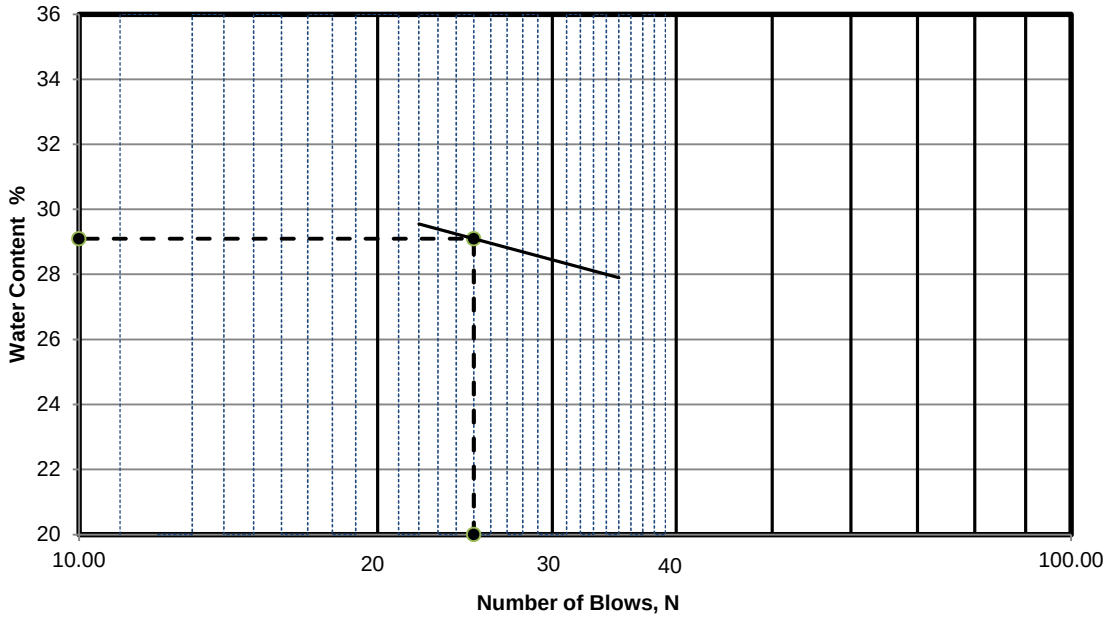
AASHTO T89-T90: Standard Method of Test for Liquid Limit, Plastic Limit, and Plasticity Index of Soil

Form Number	KL-D4318-17
Form Revision	1
Test Date	2/26/2024
Sample Date	1/23/2024

Project Number	23430366		
Project Name	Task 24: FS - 23 McFarland Road		
Client Name	Johnson, Mirmiran & Thopson, Inc.		
Client Address	40 Wright Avenue, Hunt Valley, Maryland 21030		
KeyLAB ID	81-865	Sample Type	SS
Location ID	FS-23-B2	Sample Top Depth	4
		Sample Base Depth	6
Description	Olive Gray, SILTY SAND WITH GRAVEL (ML), (A-4, 0)	Test Method	Multipoint

Type and Specification	*S&ME ID #*	*Cal Date:*	*Type and Specification*	*S&ME ID #*	*Cal Date:*
Balance (0.01 g)	22533-CL	8/29/2023	Grooving tool	34230	2/20/2024
LL Apparatus	33350	2/20/2024			
Oven	22617	9/25/2023			

		Liquid Limit						Plastic Limit		
	Tare #:	59	69	31				12		
A	Tare Weight	13.91	13.64	13.61				80.61		
B	Wet Soil Weight + A	25.54	28.45	25.87				91.87		
C	Dry Soil Weight + A	23.01	25.13	23.08				89.55		
D	Water Weight (B-C)	2.53	3.32	2.79				2.32		
E	Dry Soil Weight (C-A)	9.10	11.49	9.47				8.94		
F	% Moisture (D/E)*100	27.8	28.9	29.5				26.0		
N	# OF DROPS	35	28	22				**26.0**		



Sample Preparation:

- ○ in natural condition
- ○ dry prep
- ○ wet prep

Liquid Limit	**29**
Plastic Limit	**26**
Plastic Index	**3**
ASTM	**ML**

References / Comments / Deviations:

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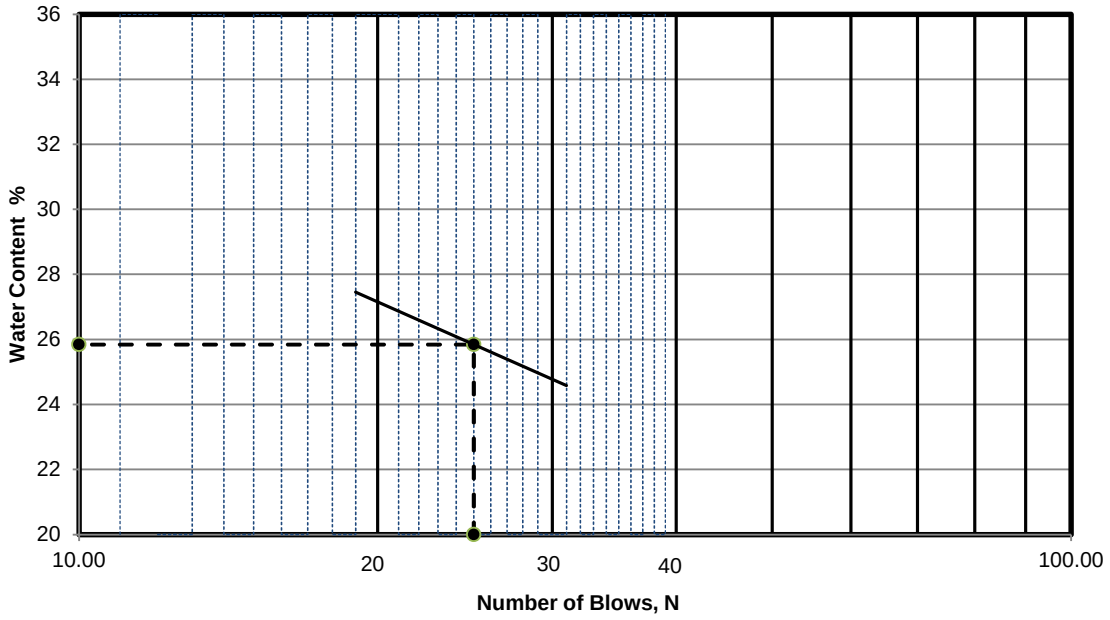
	AASHTO T89-T90: Standard Method of Test for Liquid Limit, Plastic Limit, and Plasticity Index of Soil	Form Number	**KL-D4318-17**
		Form Revision	**1**
		Test Date	2/27/2024
		Sample Date	1/23/2024

Project Number	23430366		
Project Name	Task 24: FS - 23 McFarland Road		
Client Name	Johnson, Mirmiran & Thopson, Inc.		
Client Address	40 Wright Avenue, Hunt Valley, Maryland 21030		
KeyLAB ID	81-865	Sample Type	SS
Location ID	FS-23-B3	Sample Top Depth	0
		Sample Base Depth	2
Description	Grayish Brown, SILTY, CLAYEY SAND WITH GRAVEL (SC-SM), (A-2-4,0)	Test Method	Multipoint

Type and Specification	*S&ME ID #*	*Cal Date:*	*Type and Specification*	*S&ME ID #*	*Cal Date:*
Balance (0.01 g)	22533-CL	8/29/2023	Grooving tool	34230	2/20/2024
LL Apparatus	33350	2/20/2024			
Oven	22617	9/25/2023			

		Liquid Limit						Plastic Limit		
	Tare #:	41	51	84				2		
A	Tare Weight	13.67	13.82	13.76				80.72		
B	Wet Soil Weight + A	22.18	23.28	23.04				91.20		
C	Dry Soil Weight + A	20.50	21.31	21.04				89.39		
D	Water Weight (B-C)	1.68	1.97	2.00				1.81		
E	Dry Soil Weight (C-A)	6.83	7.49	7.28				8.67		
F	% Moisture (D/E)*100	24.6	26.3	27.5				20.9		
N	# OF DROPS	31	23	19				**20.9**		



Sample Preparation:

- ○ in natural condition
- ◉ dry prep
- ○ wet prep

Liquid Limit	**26**
Plastic Limit	**21**
Plastic Index	**5**
ASTM	**CL-ML**

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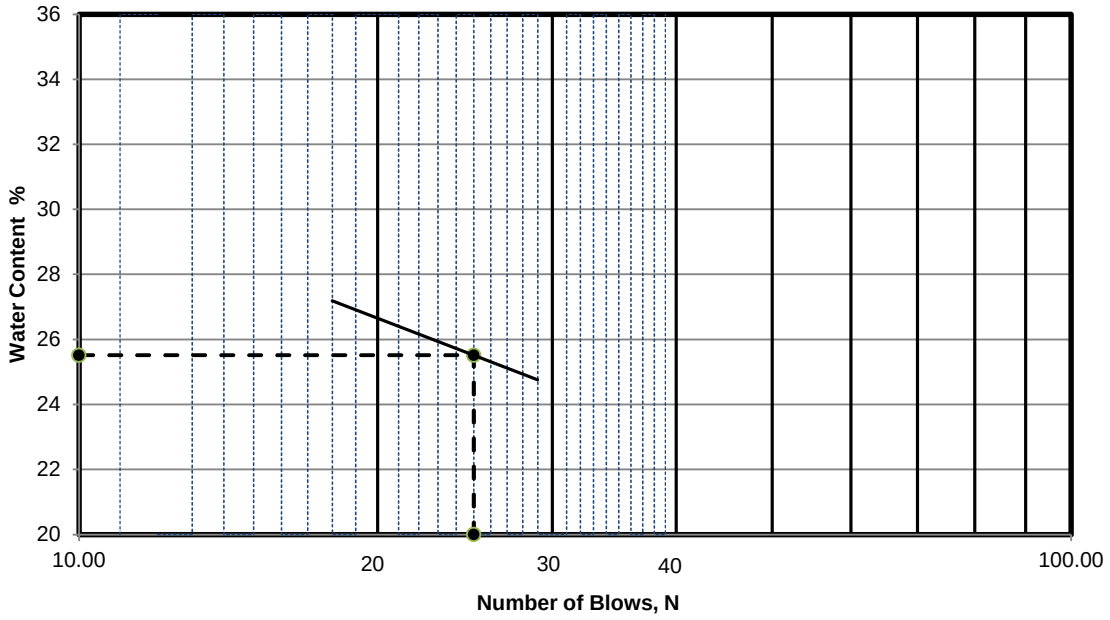
AASHTO T89-T90: Standard Method of Test for Liquid Limit, Plastic Limit, and Plasticity Index of Soil

Form Number	KL-D4318-17
Form Revision	1
Test Date	2/27/2024
Sample Date	1/23/2024

Project Number	23430366		
Project Name	Task 24: FS - 23 McFarland Road		
Client Name	Johnson, Mirmiran & Thopson, Inc.		
Client Address	40 Wright Avenue, Hunt Valley, Maryland 21030		
KeyLAB ID	81-865	Sample Type	SS
Location ID	FS-23-B3	Sample Top Depth	2
		Sample Base Depth	4
Description	Reddish Brown, SILTY, CLAYEY SAND WITH GRAVEL (SC-SM), (A-2-4, 0)	Test Method	Multipoint

Type and Specification	*S&ME ID #*	*Cal Date:*	*Type and Specification*	*S&ME ID #*	*Cal Date:*
Balance (0.01 g)	22533-CL	8/29/2023	Grooving tool	34230	2/20/2024
LL Apparatus	33350	2/20/2024			
Oven	22617	9/25/2023			

		Liquid Limit						Plastic Limit		
	Tare #:	43	44	92				18		
A	Tare Weight	13.66	13.65	13.78				80.56		
B	Wet Soil Weight + A	20.97	21.76	21.22				90.86		
C	Dry Soil Weight + A	19.52	20.11	19.63				89.19		
D	Water Weight (B-C)	1.45	1.65	1.59				1.67		
E	Dry Soil Weight (C-A)	5.86	6.46	5.85				8.63		
F	% Moisture (D/E)*100	24.7	25.5	27.2				19.4		
N	# OF DROPS	29	25	18				**19.4**		



Sample Preparation:

- ○ in natural condition
- ◉ dry prep
- ○ wet prep

Liquid Limit	**26**
Plastic Limit	**19**
Plastic Index	**7**
ASTM	**CL-ML**

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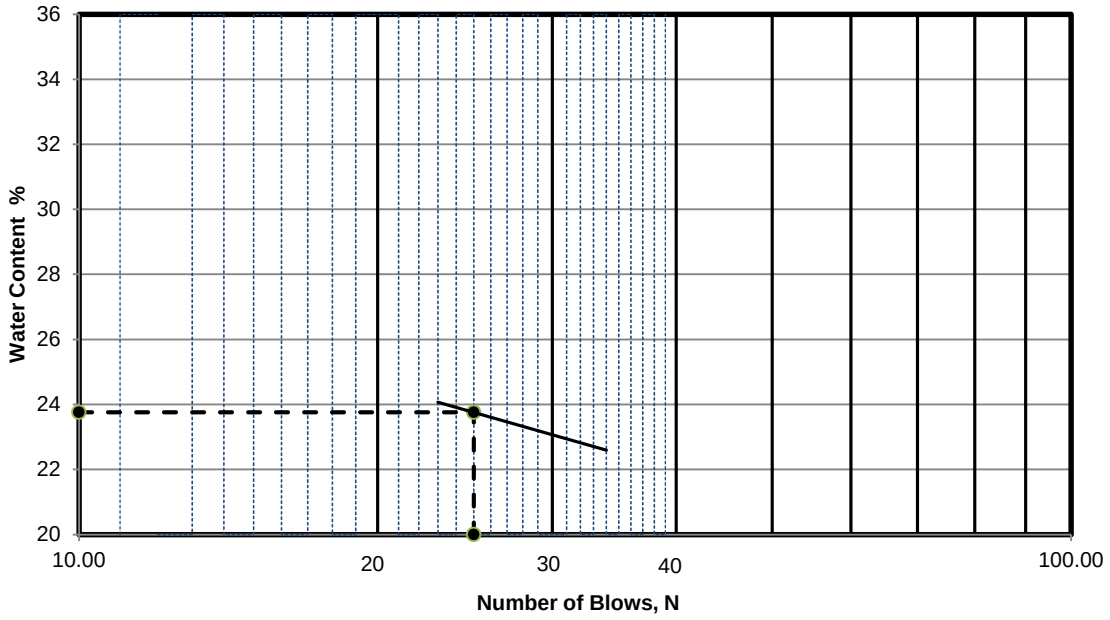
AASHTO T89-T90: Standard Method of Test for Liquid Limit, Plastic Limit, and Plasticity Index of Soil

Form Number	KL-D4318-17
Form Revision	1
Test Date	2/26/2024
Sample Date	1/23/2024

Project Number	23430366		
Project Name	Task 24: FS - 23 McFarland Road		
Client Name	Johnson, Mirmiran & Thopson, Inc.		
Client Address	40 Wright Avenue, Hunt Valley, Maryland 21030		
KeyLAB ID	81-865	Sample Type	SS
Location ID	FS-23-B3	Sample Top Depth	4
		Sample Base Depth	6
Description	Yellowish Brown, SILTY, CLAYEY SAND WITH GRAVEL (SC-SM) (A-1-b, 0)	Test Method	Multipoint

Type and Specification	*S&ME ID #*	*Cal Date:*	*Type and Specification*	*S&ME ID #*	*Cal Date:*
Balance (0.01 g)	22533-CL	8/29/2023	Grooving tool	34230	2/20/2024
LL Apparatus	33350	2/20/2024			
Oven	22617	9/25/2023			

		Liquid Limit						Plastic Limit		
	Tare #:	99	91	49				18		
A	Tare Weight	13.65	14.01	13.65				80.56		
B	Wet Soil Weight + A	22.17	21.87	22.21				90.83		
C	Dry Soil Weight + A	20.60	20.36	20.55				89.22		
D	Water Weight (B-C)	1.57	1.51	1.66				1.61		
E	Dry Soil Weight (C-A)	6.95	6.35	6.90				8.66		
F	% Moisture (D/E)*100	22.6	23.8	24.1				18.6		
N	# OF DROPS	34	25	23				**18.6**		



Sample Preparation:

- ○ in natural condition
- ◉ dry prep
- ○ wet prep

Liquid Limit	**24**
Plastic Limit	**19**
Plastic Index	**5**
ASTM	**CL-ML**

References / Comments / Deviations:

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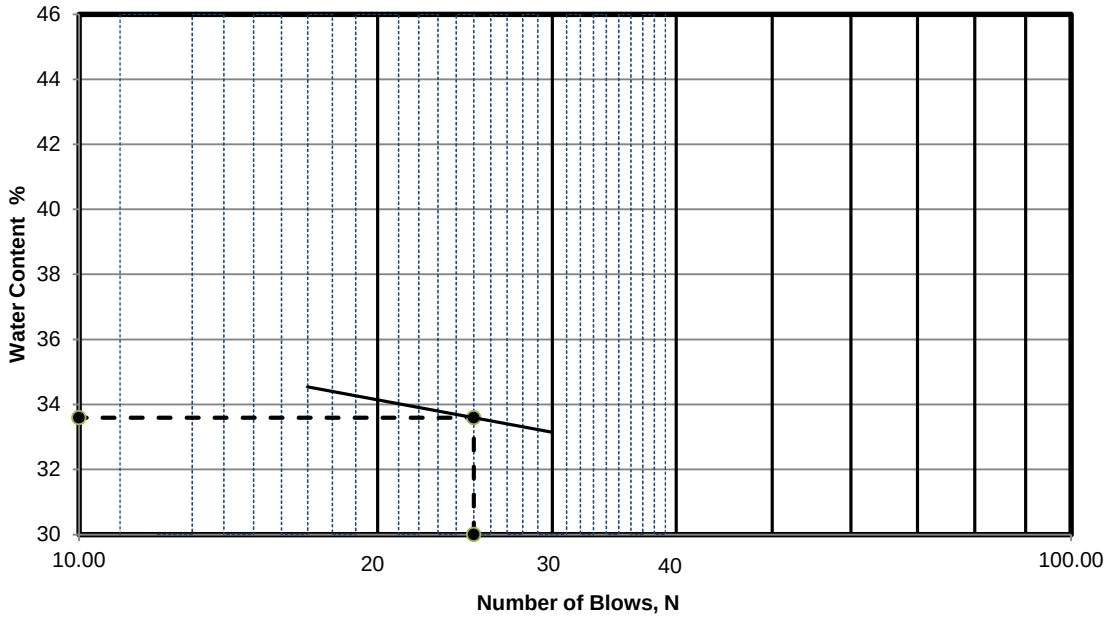
	AASHTO T89-T90: Standard Method of Test for Liquid Limit, Plastic Limit, and Plasticity Index of Soil	Form Number	**KL-D4318-17**
		Form Revision	**1**
		Test Date	2/27/2024
		Sample Date	1/23/2024

Project Number	23430366		
Project Name	Task 24: FS - 23 McFarland Road		
Client Name	Johnson, Mirmiran & Thopson, Inc.		
Client Address	40 Wright Avenue, Hunt Valley, Maryland 21030		
KeyLAB ID	81-865	Sample Type	SS
Location ID	FS-23-B6	Sample Top Depth	0
		Sample Base Depth	1.75
Description	Dark Grayish, Brown CLAYEY SAND WITH GRAVEL (SC), (A-2-6, 0)	Test Method	Multipoint

Type and Specification	*S&ME ID #*	*Cal Date:*	*Type and Specification*	*S&ME ID #*	*Cal Date:*
Balance (0.01 g)	22533-CL	8/29/2023	Grooving tool	34230	2/20/2024
LL Apparatus	33350	2/20/2024			
Oven	22617	9/25/2023			

		Liquid Limit						Plastic Limit		
	Tare #:	66	71	82				13		
A	Tare Weight	13.65	13.63	13.68				81.69		
B	Wet Soil Weight + A	21.25	20.46	21.12				92.23		
C	Dry Soil Weight + A	19.33	18.76	19.21				90.25		
D	Water Weight (B-C)	1.92	1.70	1.91				1.98		
E	Dry Soil Weight (C-A)	5.68	5.13	5.53				8.56		
F	% Moisture (D/E)*100	33.8	33.1	34.5				23.1		
N	# OF DROPS	23	30	17				**23.1**		



Sample Preparation:

- ○ in natural condition
- ◉ dry prep
- ○ wet prep

Liquid Limit	**34**
Plastic Limit	**23**
Plastic Index	**11**
ASTM	**CL**

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AASHTO T88: Particle Size Analysis of Soils

Report Number	**CHAT_24001010**
Report Date	**2/29/2024**
Test Date	**2/28/2024**
Sample Date	**1/23/2024**

Project Number	23430366		
Project Name	Task 24: FS - 23 McFarland Road		
Client Name	Johnson, Mirmiran & Thopson, Inc.		
Client Address	40 Wright Avenue, Hunt Valley, Maryland 21030		
KeyLAB ID	81-865	Sample Type	SS
Location ID	FS-23-B1	Sample Top Depth	2
		Sample Base Depth	4
Description	Light Brown	Method	AASHTO T 88
Classification	SANDY SILT WITH GRAVEL		**A-4, 1**

ASTM PARTICLE SIZE DEFINITIONS			
Cobbles	< 300 mm (12") and > 75 mm (3")	Medium Sand	< 2.00 mm and > 0.425 mm (#40)
Gravel	< 75 mm and > 4.75 mm (#4)	Fine Sand	< 0.425 mm and > 0.075 mm
Coarse Sand	< 4.75 mm and >2.00 mm (#10)	Silt & Clay	< 0.075

Maximum Particle Size	**19 mm**	Coarse Sand	5.6	Fine Sand	7.5
Gravel	19.0	Medium Sand	9.9	Silt & Clay	58.0
Liquid Limit	30	Plastic Limit	26	Plastic Index	4

Description of Sand & Gravel Particles: Rounded ☐ Angular ☒

Hard & Durable ☐ Soft ☐ Weathered & Friable ☒

References / Comments / Deviations:

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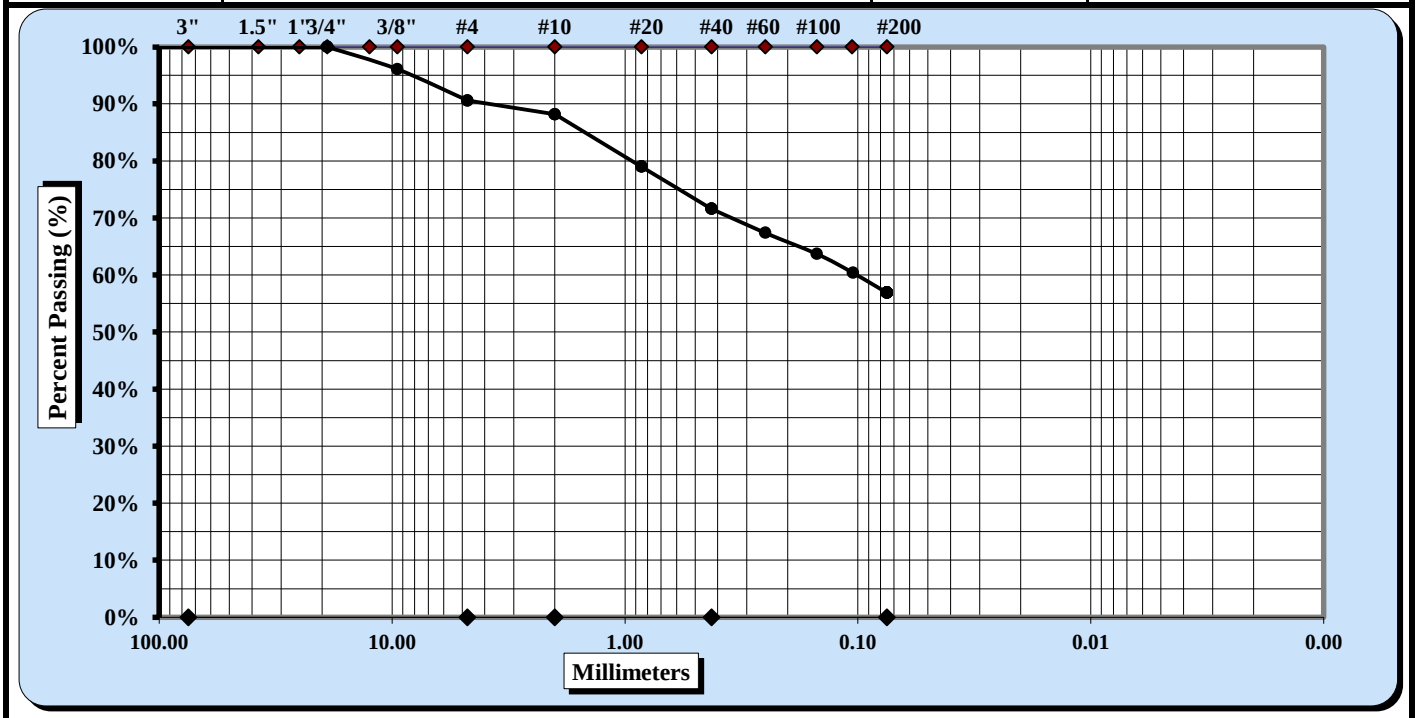
AASHTO T88: Particle Size Analysis of Soils

Report Number	**CHAT_24001011**
Report Date	**2/29/2024**
Test Date	**2/28/2024**
Sample Date	**1/23/2024**

Project Number	23430366		
Project Name	Task 24: FS - 23 McFarland Road		
Client Name	Johnson, Mirmiran & Thopson, Inc.		
Client Address	40 Wright Avenue, Hunt Valley, Maryland 21030		
KeyLAB ID	81-865	Sample Type	SS
Location ID	FS-23-B1	Sample Top Depth	8.5
		Sample Base Depth	10
Description	Gray	Method	AASHTO T 88
Classification	SANDY SILT (ML)		**A-4, 0**



ASTM PARTICLE SIZE DEFINITIONS

Cobbles	< 300 mm (12") and > 75 mm (3")	Medium Sand	< 2.00 mm and > 0.425 mm (#40)
Gravel	< 75 mm and > 4.75 mm (#4)	Fine Sand	< 0.425 mm and > 0.075 mm
Coarse Sand	< 4.75 mm and >2.00 mm (#10)	Silt & Clay	< 0.075

Maximum Particle Size	**19 mm**	Coarse Sand	2.4	Fine Sand	14.7
Gravel	9.4	Medium Sand	16.6	Silt & Clay	56.9
Liquid Limit	30	Plastic Limit	28	Plastic Index	2

Description of Sand & Gravel Particles: Rounded ☐ Angular ☐

Hard & Durable ☐ Soft ☐ Weathered & Friable ☐

References / Comments / Deviations:

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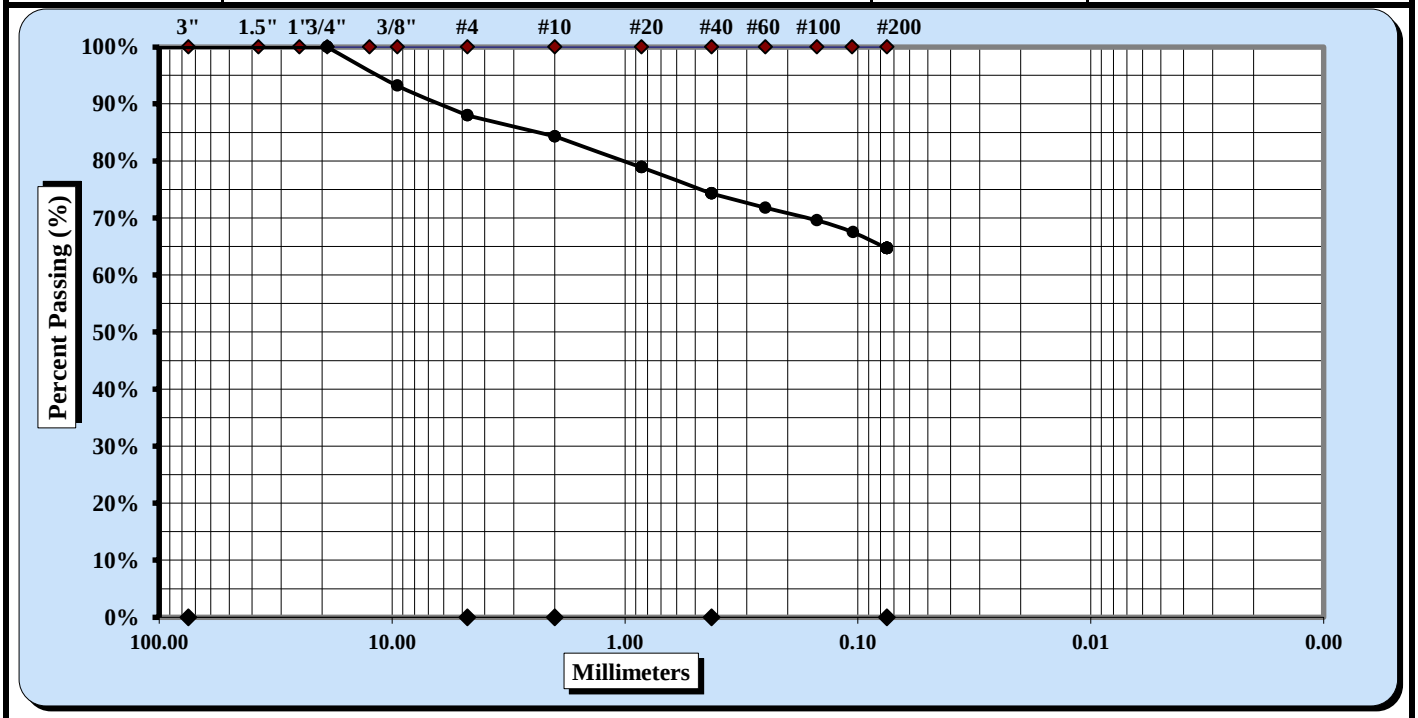
AASHTO T88: Particle Size Analysis of Soils

Report Number	**CHAT_24001012**
Report Date	**2/29/2024**
Test Date	**2/28/2024**
Sample Date	**1/23/2024**

Project Number	23430366		
Project Name	Task 24: FS - 23 McFarland Road		
Client Name	Johnson, Mirmiran & Thopson, Inc.		
Client Address	40 Wright Avenue, Hunt Valley, Maryland 21030		
KeyLAB ID	81-865	Sample Type	SS
Location ID	FS-23-B1	Sample Top Depth	18.5
		Sample Base Depth	20
Description	Olive Brown	Method	AASHTO T 88
Classification	SANDY SILT (ML)		**A-4, 1**



ASTM PARTICLE SIZE DEFINITIONS			
Cobbles	< 300 mm (12") and > 75 mm (3")	Medium Sand	< 2.00 mm and > 0.425 mm (#40)
Gravel	< 75 mm and > 4.75 mm (#4)	Fine Sand	< 0.425 mm and > 0.075 mm
Coarse Sand	< 4.75 mm and >2.00 mm (#10)	Silt & Clay	< 0.075

Maximum Particle Size	**19 mm**	Coarse Sand	3.7	Fine Sand	9.6
Gravel	12.0	Medium Sand	10.0	Silt & Clay	64.7
Liquid Limit	31	Plastic Limit	29	Plastic Index	2

Description of Sand & Gravel Particles: Rounded ☐ Angular ☒

Hard & Durable ☐ Soft ☐ Weathered & Friable ☒

References / Comments / Deviations:

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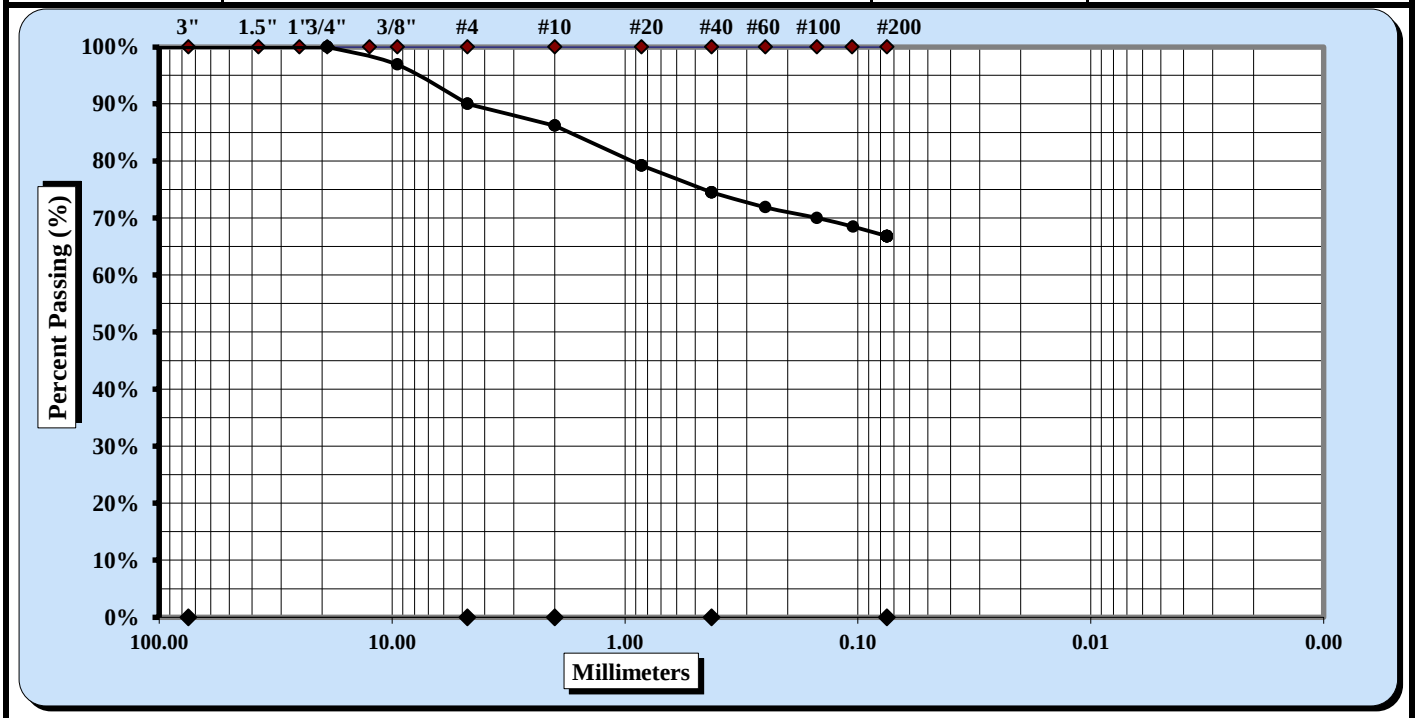
AASHTO T88: Particle Size Analysis of Soils

Report Number	**CHAT_24001013**
Report Date	**2/29/2024**
Test Date	**2/28/2024**
Sample Date	**1/23/2024**

Project Number	23430366		
Project Name	Task 24: FS - 23 McFarland Road		
Client Name	Johnson, Mirmiran & Thopson, Inc.		
Client Address	40 Wright Avenue, Hunt Valley, Maryland 21030		
KeyLAB ID	81-865	Sample Type	SS
Location ID	FS-23-B2	Sample Top Depth	2
		Sample Base Depth	4
Description	Olive Brown	Method	AASHTO T 88
Classification	SANDY SILT (ML)		**A-4, 2**



ASTM PARTICLE SIZE DEFINITIONS

Cobbles	< 300 mm (12") and > 75 mm (3")	Medium Sand	< 2.00 mm and > 0.425 mm (#40)
Gravel	< 75 mm and > 4.75 mm (#4)	Fine Sand	< 0.425 mm and > 0.075 mm
Coarse Sand	< 4.75 mm and >2.00 mm (#10)	Silt & Clay	< 0.075

Maximum Particle Size	**19 mm**	Coarse Sand	3.8	Fine Sand	7.7
Gravel	10.0	Medium Sand	11.7	Silt & Clay	66.8
Liquid Limit	29	Plastic Limit	24	Plastic Index	5

Description of Sand & Gravel Particles: Rounded ☐ Angular ☒

Hard & Durable ☐ Soft ☐ Weathered & Friable ☒

References / Comments / Deviations:

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AASHTO T88: Particle Size Analysis of Soils

Report Number	**CHAT_24001014**
Report Date	**2/29/2024**
Test Date	**2/28/2024**
Sample Date	**1/23/2024**

Project Number	23430366		
Project Name	Task 24: FS - 23 McFarland Road		
Client Name	Johnson, Mirmiran & Thopson, Inc.		
Client Address	40 Wright Avenue, Hunt Valley, Maryland 21030		
KeyLAB ID	81-865	Sample Type	SS
Location ID	FS-23-B2	Sample Top Depth	4
		Sample Base Depth	6
Description	Olive Gray	Method	AASHTO T 88
Classification	SILTY SAND WITH GRAVEL (SM)		**A-4, 0**

ASTM PARTICLE SIZE DEFINITIONS

Cobbles	< 300 mm (12") and > 75 mm (3")	Medium Sand	< 2.00 mm and > 0.425 mm (#40)
Gravel	< 75 mm and > 4.75 mm (#4)	Fine Sand	< 0.425 mm and > 0.075 mm
Coarse Sand	< 4.75 mm and >2.00 mm (#10)	Silt & Clay	< 0.075

Maximum Particle Size	**19 mm**	Coarse Sand	7.7	Fine Sand	9.2
Gravel	31.0	Medium Sand	16.5	Silt & Clay	35.6
Liquid Limit	29	Plastic Limit	26	Plastic Index	3

Description of Sand & Gravel Particles: Rounded ☐ Angular ☒

Hard & Durable ☐ Soft ☒ Weathered & Friable ☐

References / Comments / Deviations:

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Tested by	*Approved by*	*Signature*
Chattanooga	*4291 Highway 58, Suite 101, Chattanooga, TN 37416*	

AASHTO T88: Particle Size Analysis of Soils

Report Number	**CHAT_24001015**
Report Date	**2/29/2024**
Test Date	**2/28/2024**
Sample Date	**1/23/2024**

Project Number	23430366		
Project Name	Task 24: FS - 23 McFarland Road		
Client Name	Johnson, Mirmiran & Thopson, Inc.		
Client Address	40 Wright Avenue, Hunt Valley, Maryland 21030		
KeyLAB ID	81-865	Sample Type	SS
Location ID	FS-23-B3	Sample Top Depth	0
		Sample Base Depth	2
Description	Grayish Brown	Method	AASHTO T 88
Classification	SILTY, CLAYEY SAND WITH GRAVEL (SC-SM)		**A-2-4, 0**

ASTM PARTICLE SIZE DEFINITIONS

Cobbles	< 300 mm (12") and > 75 mm (3")	Medium Sand	< 2.00 mm and > 0.425 mm (#40)
Gravel	< 75 mm and > 4.75 mm (#4)	Fine Sand	< 0.425 mm and > 0.075 mm
Coarse Sand	< 4.75 mm and >2.00 mm (#10)	Silt & Clay	< 0.075

Maximum Particle Size	**25 mm**	Coarse Sand	8.9	Fine Sand	15.0
Gravel	25.2	Medium Sand	22.6	Silt & Clay	28.3
Liquid Limit	26	Plastic Limit	21	Plastic Index	5

Description of Sand & Gravel Particles: Rounded ☐ Angular ☒

Hard & Durable ☐ Soft ☐ Weathered & Friable ☒

References / Comments / Deviations:

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AASHTO T88: Particle Size Analysis of Soils

Report Number	**CHAT_24001016**
Report Date	**2/29/2024**
Test Date	**2/28/2024**
Sample Date	**1/23/2024**

Project Number	23430366		
Project Name	Task 24: FS - 23 McFarland Road		
Client Name	Johnson, Mirmiran & Thopson, Inc.		
Client Address	40 Wright Avenue, Hunt Valley, Maryland 21030		
KeyLAB ID	81-865	Sample Type	SS
Location ID	FS-23-B3	Sample Top Depth	2
		Sample Base Depth	4
Description	Reddish Brown	Method	AASHTO T 88
Classification	SILTY, CLAYEY SAND WITH GRAVEL (SC-SM)		**A-2-4, 0**

ASTM PARTICLE SIZE DEFINITIONS

Cobbles	< 300 mm (12") and > 75 mm (3")	Medium Sand	< 2.00 mm and > 0.425 mm (#40)
Gravel	< 75 mm and > 4.75 mm (#4)	Fine Sand	< 0.425 mm and > 0.075 mm
Coarse Sand	< 4.75 mm and >2.00 mm (#10)	Silt & Clay	< 0.075

Maximum Particle Size	**25 mm**	Coarse Sand	8.1	Fine Sand	14.1
Gravel	28.2	Medium Sand	22.7	Silt & Clay	26.9
Liquid Limit	26	Plastic Limit	19	Plastic Index	7

Description of Sand & Gravel Particles: Rounded ☐ Angular ☒

Hard & Durable ☐ Soft ☐ Weathered & Friable ☒

References / Comments / Deviations:

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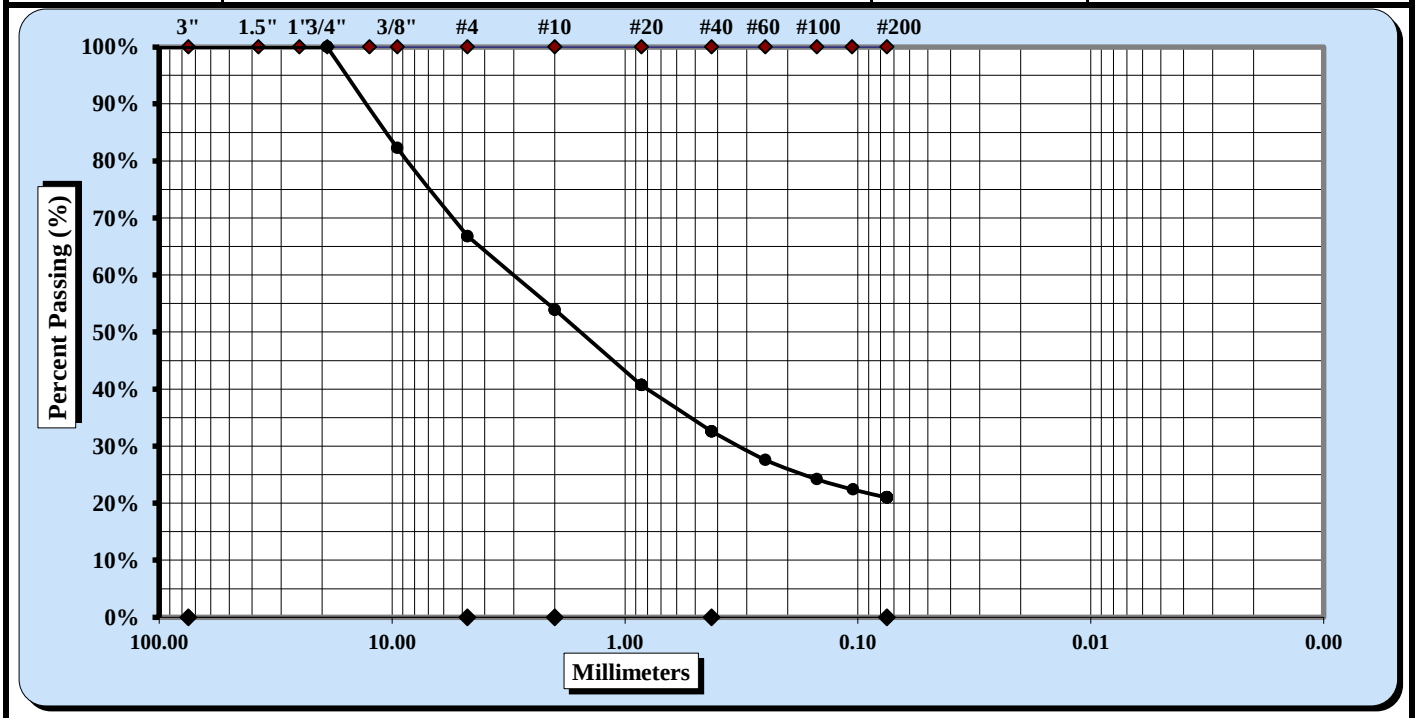
AASHTO T88: Particle Size Analysis of Soils

Report Number	**CHAT_24001017**
Report Date	**2/29/2024**
Test Date	**2/28/2024**
Sample Date	**1/23/2024**

Project Number	23430366		
Project Name	Task 24: FS - 23 McFarland Road		
Client Name	Johnson, Mirmiran & Thopson, Inc.		
Client Address	40 Wright Avenue, Hunt Valley, Maryland 21030		
KeyLAB ID	81-865	Sample Type	SS
Location ID	FS-23-B3	Sample Top Depth	4
		Sample Base Depth	6
Description	Yellowish Brown	Method	AASHTO T 88
Classification	SILTY, CLAYEY SAND WITH GRAVEL (SC-SM)		**A-1-b, 0**



ASTM PARTICLE SIZE DEFINITIONS

Cobbles	< 300 mm (12") and > 75 mm (3")	Medium Sand	< 2.00 mm and > 0.425 mm (#40)
Gravel	< 75 mm and > 4.75 mm (#4)	Fine Sand	< 0.425 mm and > 0.075 mm
Coarse Sand	< 4.75 mm and >2.00 mm (#10)	Silt & Clay	< 0.075

Maximum Particle Size	**19 mm**	Coarse Sand	12.9	Fine Sand	11.6
Gravel	33.2	Medium Sand	21.3	Silt & Clay	21.0
Liquid Limit	24	Plastic Limit	19	Plastic Index	5

Description of Sand & Gravel Particles: Rounded ☐ Angular ☒

Hard & Durable ☐ Soft ☐ Weathered & Friable ☒

References / Comments / Deviations:

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AASHTO T88: Particle Size Analysis of Soils

Report Number	**CHAT_24001018**
Report Date	**2/29/2024**
Test Date	**2/28/2024**
Sample Date	**1/23/2024**

Project Number	23430366		
Project Name	Task 24: FS - 23 McFarland Road		
Client Name	Johnson, Mirmiran & Thopson, Inc.		
Client Address	40 Wright Avenue, Hunt Valley, Maryland 21030		
KeyLAB ID	81-865	Sample Type	SS
Location ID	FS-23-B6	Sample Top Depth	0
		Sample Base Depth	1.75
Description	Dark Grayish	Method	AASHTO T 88
Classification	CLAYEY SAND WITH GRAVEL (SC)		**A-2-6, 0**

ASTM PARTICLE SIZE DEFINITIONS

Cobbles	< 300 mm (12") and > 75 mm (3")	Medium Sand	< 2.00 mm and > 0.425 mm (#40)
Gravel	< 75 mm and > 4.75 mm (#4)	Fine Sand	< 0.425 mm and > 0.075 mm
Coarse Sand	< 4.75 mm and >2.00 mm (#10)	Silt & Clay	< 0.075

Maximum Particle Size	**19 mm**	Coarse Sand	13.3	Fine Sand	9.5
Gravel	32.6	Medium Sand	19.9	Silt & Clay	24.7
Liquid Limit	34	Plastic Limit	23	Plastic Index	11

Description of Sand & Gravel Particles: Rounded ☐ Angular ☒

Hard & Durable ☐ Soft ☒ Weathered & Friable ☐

References / Comments / Deviations:

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TThompson	TThompson	
Tested by	*Approved by*	*Signature*
Chattanooga	*4291 Highway 58, Suite 101, Chattanooga, TN 37416*	

Results Only Soil Testing for McFarland Road

February 20, 2024

Prepared for:

Pen Sibley
S&ME, Inc.
4291 TN Highway 58
Chattanooga, TN 37415
psibley@smeinc.com

Project X Job#: S240219G
Client Job or PO#: 23430366

Prepared by:
NRabatin

Respectfully Submitted,

Eduardo Hernandez, M.Sc., P.E.
Sr. Corrosion Consultant
NACE Corrosion Technologist #16592
Professional Engineer
California No. M37102
ehernandez@projectxcorrosion.com

Soil Analysis Lab Results

Client: S&ME, Inc.
Job Name: McFarland Road
Client Job Number: 23430366
Project X Job Number: S240219G
February 20, 2024

	Method	ASTM D4327		ASTM D4327		ASTM G187		ASTM G51
Bore# / Description	**Depth**	**Sulfates** SO_4^{2-}		**Chlorides** Cl^-		**Resistivity** As Rec'd | Minimum		**pH**
	(ft)	(mg/kg)	(wt%)	(mg/kg)	(wt%)	(Ohm-cm)	(Ohm-cm)	
B-01 S-05	13.5-15	2.3	0.0002	5.0	0.0005	36,180	27,470	8.9
B-05 S-01, S-02 (combined)	1-5	33.2	0.0033	6.6	0.0007	63,000	13,050	7.2
B-07 S-01, S-02 (combined)	1-3	554.0	0.0554	34.4	0.0034	21,000	2,550	6.8

Cations and Anions, except Sulfide and Bicarbonate, tested with Ion Chromatography
mg/kg = milligrams per kilogram (parts per million) of dry soil weight
ND = 0 = Not Detected | NT = Not Tested | Unk = Unknown
Chemical Analysis performed on 1:3 Soil-To-Water extract
PPM = mg/kg (soil) = mg/L (Liquid)

Note: Sometimes a bad sulfate hit is a contaminated spot. Typical fertilizers are Potassium chloride, ammonium sulfate or ammonium sulfate nitrate (ASN). So this is another reason why testing full corrosion series is good because we then have the data to see if those other ingredients are present meaning the soil sample is just fertilizer-contaminated soil. This can happen often when the soil samples collected are simply surface scoops which is why it's best to dig in a foot, throw away the top and test the deeper stuff. Dairy farms are also notorious for these items.

Form No. TR-43-D7012C-02
Revision No. : 0
Revision Date: 08/22/18

UNCONFINED COMPRESSION
(ASTM D7012 Method C)

S&ME, Inc. - Knoxville 1413 Topside Road, Louisville, TN 37777

Project Name: FS - 23 Mcfarland Road
Project Number: 23430366

Report Date: February 23, 2024
Reviewed By: Tyler Copeman

Boring No.	Sample No.	Depth (ft)	Dimensions, in.		Shape (See Key)	Area (in^2)	Unit Weight (lbs/ft^3)	Loading Rate (psi/sec)	Maximum Load (lbs)	Strength (psi)	Moisture (%)
			Length	Diameter							
FS-23-B2	Run-03	20.0-20.4	4.19	1.98	A	3.08	172.8	91	42,887	13,924	1.5
FS-23-B3	Run-01	5.6-6.0	4.17	1.98	A	3.08	166.2	99	100,809	32,730	0.1
FS-23-B4	Run-02	4.8-5.2	4.33	1.98	A	3.08	168.5	96	87,386	28,372	0.1
FS-23-B6	Run-02	7.9-8.3	4.36	1.98	A	3.08	175.7	79	16,861	5,474	0.1
FS-23-B7	Run-01	3.5-3.9	4.28	1.98	A	3.08	174.4	32	3,880	1,260	0.1

NOTES: Effective (as received) unit weight as determined by RTH 109-93.
Loading rates were selected to target reaching failure between 2 and 15 minutes.
Test results for specimens not meeting the requirements of ASTM D4543-19 may differ from a test specimen that meets the requirements of ASTM D4543.

SHAPE KEY

ASTM D4543-19 Standard Practice for Preparing Rock Core as Cylindrical Test Specimens and Verifying Conformance to Dimensional and Shape Tolerance Section 1.2 - "Rock is a complex engineering material that can vary greatly as a function of lithology, stress history, weathering, moisture content and chemistry, and other natural geologic processes. As such, it is not always possible to obtain or prepare rock core specimens that satisfy the desirable tolerances given in this practice. Most commonly, this situation presents itself with weaker, more porous, and poorly cemented rock types and rock types containing significant or weak (or both) structural features. For rock types which are difficult to prepare, all reasonable efforts shall be made to prepare a specimen in accordance with this practice and for the intended test procedure. However, when it has been determined by trial and error that this is not possible, prepare the rock specimen to the closest tolerances practicable and consider this to be the best effort and report it as such and if allowable or necessary for the intended test, capping the ends of the specimen as discussed in this practice is permitted."

A Test specimen measurements met the desired shape tolerances of ASTM D4543-19 (side straightness, end flatness & parallelism, and end perpendicularity to axis)

B Test specimen measurements met the desired shape tolerances of ASTM D4543-19 for end flatness & parallelism, and end perpendicularity to axis. Specimen did not meet the desired tolerance for side straightness. Specimen prepared to closest tolerances practicable.

C Test specimen measurements met the desired shape tolerances of ASTM D4543-19 for end flatness & parallelism. Specimen did not meet the desired tolerances for side straightness and end perpendicularity to axis. Specimen prepared to closest tolerances practicable.

D Test specimen measurements met the desired shape tolerances of ASTM D4543-19 for end flatness. Specimen did not meet the desired tolerances for side straightness, parallelism and end perpendicularity to axis. Specimen prepared to closest tolerances practicable.

E Test specimen measurements met the desired shape tolerances of ASTM D4543-19 for end flatness and end perpendicularity to axis. Specimen did not meet the desired tolerance for side straightness and parallelism. Specimen prepared to closest tolerances practicable.

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PREPARING ROCK CORE AS CYLINDRICAL TEST SPECIMENS AND VERIFYING CONFORMANCE TO DIMENSIONAL AND SHAPE TOLERANCES
(ASTM D4543)

1413 Topside Road, Louisville, TN 37777

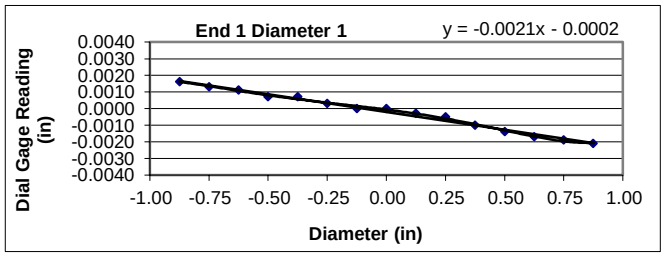
Project:	FS-23 Mcfarland Road	**Diameter (in):**	1.98	**Date:**	2/23/2024
Project No.:	23430366	**Length (in):**	4.19	**Tested by:**	Ryan Skinner
Boring Id:	FS-23-B2	**Unit Weight (pcf):**	172.8	**Reviewed by:**	Tyler Copeman
Sample No.:	Run-3	**Moisture Content (%):**	1.5		
Depth (ft):	20.0-20.4				

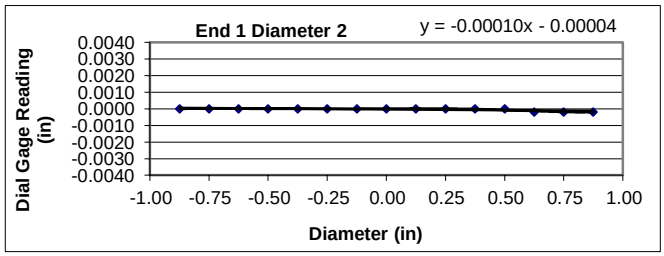
Deviation From Straightness (Procedure S1)

Is the maximum gap ≤ 0.02 in.? **YES** Straightness Tolerance Met? **YES**

End Flatness and Parallelism Readings (Procedure FP1)

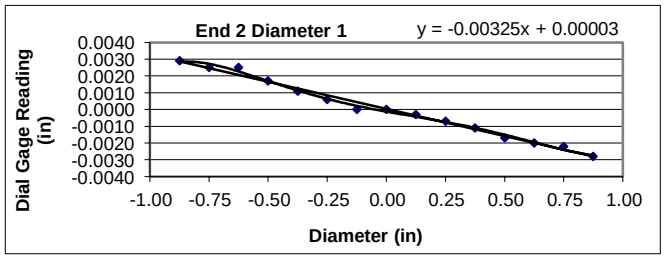
Position	End 1	End 1(90)	End 2	End 2(90)
- 7/8	0.0016	0.0000	0.0029	0.0005
- 6/8	0.0013	0.0000	0.0025	0.0004
- 5/8	0.0011	0.0000	0.0025	0.0001
- 4/8	0.0007	0.0000	0.0017	0.0001
- 3/8	0.0007	0.0000	0.0011	0.0000
- 2/8	0.0003	0.0000	0.0006	0.0000
- 1/8	0.0000	0.0000	0.0000	0.0000
0	0.0000	0.0000	0.0000	0.0000
1/8	-0.0003	0.0000	-0.0003	0.0000
2/8	-0.0005	0.0000	-0.0007	-0.0003
3/8	-0.0010	0.0000	-0.0011	-0.0003
4/8	-0.0014	0.0000	-0.0017	-0.0003
5/8	-0.0017	-0.0002	-0.0020	-0.0003
6/8	-0.0019	-0.0002	-0.0022	-0.0003
7/8	-0.0021	-0.0002	-0.0028	-0.0003

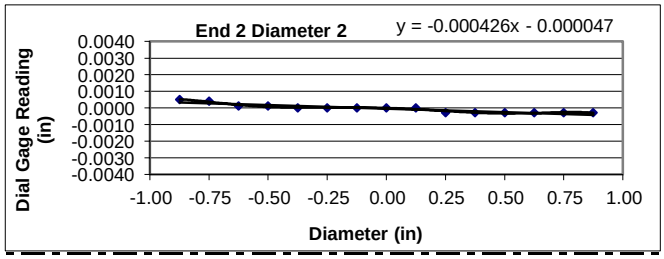




Flatness is met when the difference at any point between a smooth curve drawn through points and a visual best fit line is ≤ 0.001 in.

Flatness Tolerance Met? **YES**





Parallelism is met when the angular difference between best fit lines on opposing ends is ≤ 0.25°.

Parrallelism Diameter 1

End 1:	Slope of Best Fit Line:	-0.00213
	Angle of Best Fit Line:	-0.12196
End 2:	Slope of Best Fit Line:	-0.00325
	Angle of Best Fit Line:	-0.18613
	Max Angular Difference:	**0.06**

Parrallelism Diameter 2

End 1:	Slope of Best Fit Line:	-0.00010
	Angle of Best Fit Line:	-0.00589
End 2:	Slope of Best Fit Line:	-0.00043
	Angle of Best Fit Line:	-0.02439
	Max Angular Difference:	**0.02**

Parallelism Tolerance Met? **YES**

Perpendicularity (Procedure P1) is met when the difference between max and min readings along each line divided by the diameter is ≤ 0.0043.

	Difference b/w max & min	Divide by Diameter	Meets Tolerance
End 1 Diam 1	0.0037	0.0019	**YES**
End 1 Diam 2	0.0002	0.0001	**YES**
End 2 Diam 1	0.0057	0.0029	**YES**
End 2 Diam 2	0.0008	0.0004	**YES**

Perpendicularity Tolerance Met? **YES**

PREPARING ROCK CORE AS CYLINDRICAL TEST SPECIMENS AND VERIFYING CONFORMANCE TO DIMENSIONAL AND SHAPE TOLERANCES (ASTM D4543)

1413 Topside Road, Louisville, TN 37777

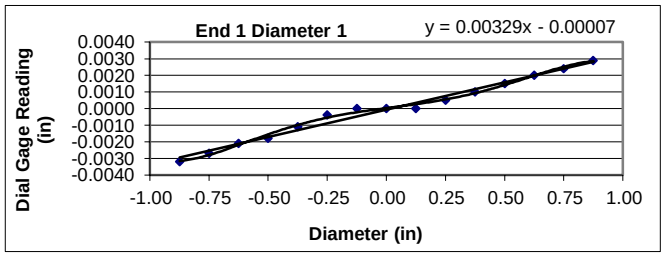
Project:	FS-23 Mcfarland Road	**Diameter (in):**	1.98	**Date:**	2/23/2024
Project No.:	23430366	**Length (in):**	4.17	**Tested by:**	Ryan Skinner
Boring Id:	FS-23-B3	**Unit Weight (pcf):**	166.2	**Reviewed by:**	Tyler Copeman
Sample No.:	Run-01	**Moisture Content (%):**	0.1		
Depth (ft):	5.6 - 6.0				

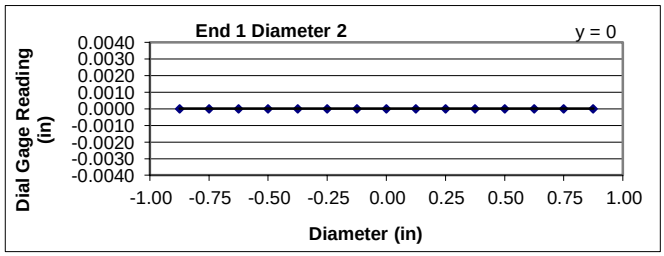
Deviation From Straightness (Procedure S1)

Is the maximum gap ≤ 0.02 in.? **YES** Straightness Tolerance Met? **YES**

End Flatness and Parallelism Readings (Procedure FP1)

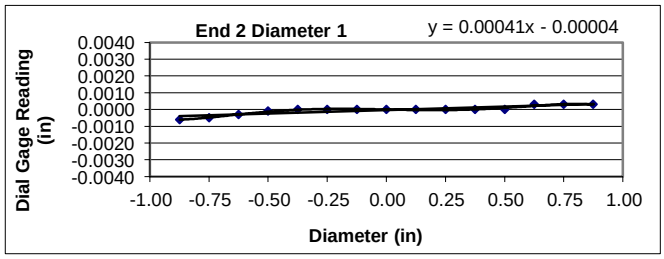
Position	End 1	End 1(90)	End 2	End 2(90)
- 7/8	-0.0032	0.0000	-0.0006	0.0001
- 6/8	-0.0027	0.0000	-0.0005	0.0001
- 5/8	-0.0021	0.0000	-0.0003	0.0001
- 4/8	-0.0018	0.0000	-0.0001	0.0001
- 3/8	-0.0011	0.0000	0.0000	0.0001
- 2/8	-0.0004	0.0000	0.0000	0.0001
- 1/8	0.0000	0.0000	0.0000	0.0001
0	0.0000	0.0000	0.0000	0.0000
1/8	0.0000	0.0000	0.0000	0.0000
2/8	0.0005	0.0000	0.0000	-0.0002
3/8	0.0010	0.0000	0.0000	-0.0002
4/8	0.0015	0.0000	0.0000	-0.0003
5/8	0.0020	0.0000	0.0003	-0.0004
6/8	0.0024	0.0000	0.0003	-0.0004
7/8	0.0029	0.0000	0.0003	-0.0006

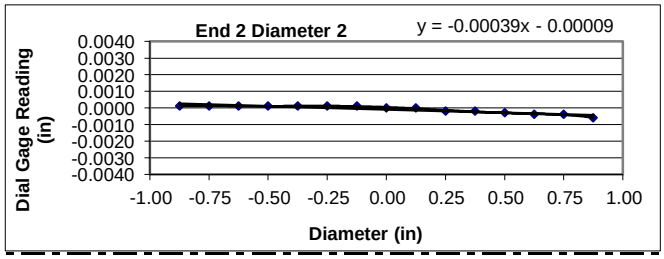




Flatness is met when the difference at any point between a smooth curve drawn through points and a visual best fit line is ≤ 0.001 in.

Flatness Tolerance Met? **YES**





Parallelism is met when the angular difference between best fit lines on opposing ends is ≤ 0.25°.

Parrallelism Diameter 1

End 1:	Slope of Best Fit Line:	0.00329
	Angle of Best Fit Line:	0.18842
End 2:	Slope of Best Fit Line:	0.00041
	Angle of Best Fit Line:	0.02374
	Max Angular Difference:	**0.16**

Parrallelism Diameter 2

End 1:	Slope of Best Fit Line:	0.00000
	Angle of Best Fit Line:	0.00000
End 2:	Slope of Best Fit Line:	-0.00039
	Angle of Best Fit Line:	-0.02226
	Max Angular Difference:	**0.02**

Parallelism Tolerance Met? **YES**

Perpendicularity (Procedure P1) is met when the difference between max and min readings along each line divided by the diameter is ≤ 0.0043.

	Difference b/w max & min	Divide by Diameter	Meets Tolerance
End 1 Diam 1	0.0061	0.0031	**YES**
End 1 Diam 2	0.0000	0.0000	**YES**
End 2 Diam 1	0.0009	0.0005	**YES**
End 2 Diam 2	0.0007	0.0004	**YES**

Perpendicularity Tolerance Met? **YES**

PREPARING ROCK CORE AS CYLINDRICAL TEST SPECIMENS AND VERIFYING CONFORMANCE TO DIMENSIONAL AND SHAPE TOLERANCES (ASTM D4543)

1413 Topside Road, Louisville, TN 37777

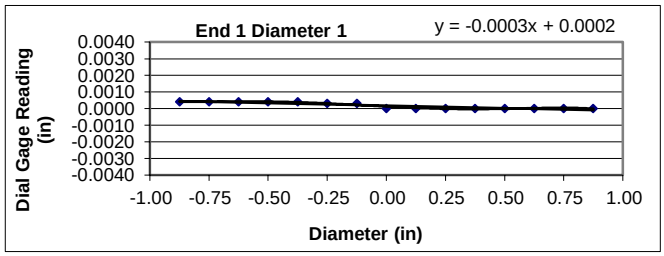
Project:	FS-23 Mcfarland Road	**Diameter (in):**	1.98	**Date:**	2/23/2024
Project No.:	23430366	**Length (in):**	4.33	**Tested by:**	Ryan Skinner
Boring Id:	FS-23-B4	**Unit Weight (pcf):**	168.5	**Reviewed by:**	Tyler Copeman
Sample No.:	Run-02	**Moisture Content (%):**	0.1		
Depth (ft):	4.8 - 5.2				

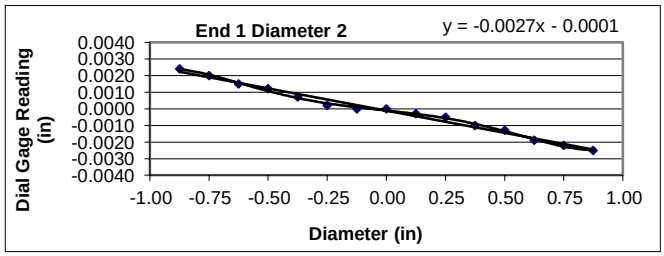
Deviation From Straightness (Procedure S1)

Is the maximum gap ≤ 0.02 in.? **YES** Straightness Tolerance Met? **YES**

End Flatness and Parallelism Readings (Procedure FP1)

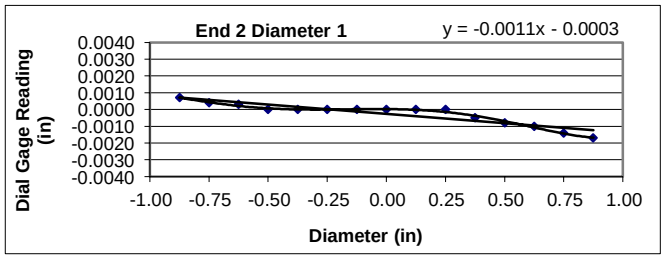
Position	End 1	End 1(90)	End 2	End 2(90)
- 7/8	0.0004	0.0024	0.0007	0.0029
- 6/8	0.0004	0.0020	0.0004	0.0024
- 5/8	0.0004	0.0015	0.0003	0.0018
- 4/8	0.0004	0.0012	0.0000	0.0013
- 3/8	0.0004	0.0007	0.0000	0.0010
- 2/8	0.0003	0.0002	0.0000	0.0005
- 1/8	0.0003	0.0000	0.0000	0.0002
0	0.0000	0.0000	0.0000	0.0000
1/8	0.0000	-0.0003	0.0000	-0.0002
2/8	0.0000	-0.0005	0.0000	-0.0004
3/8	0.0000	-0.0010	-0.0005	-0.0008
4/8	0.0000	-0.0013	-0.0008	-0.0011
5/8	0.0000	-0.0019	-0.0010	-0.0017
6/8	0.0000	-0.0022	-0.0014	-0.0022
7/8	0.0000	-0.0025	-0.0017	-0.0025

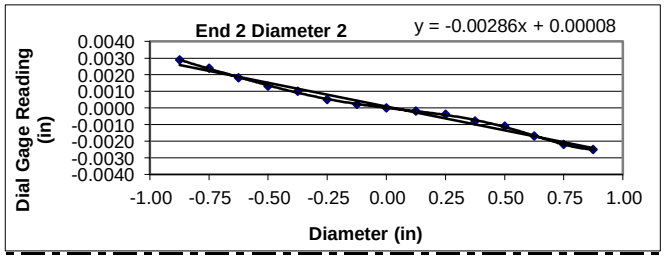




Flatness is met when the difference at any point between a smooth curve drawn through points and a visual best fit line is ≤ 0.001 in.

Flatness Tolerance Met? **YES**





Parallelism is met when the angular difference between best fit lines on opposing ends is ≤ 0.25°.

Parrallelism Diameter 1

End 1:	Slope of Best Fit Line:	-0.00031
	Angle of Best Fit Line:	-0.01784
End 2:	Slope of Best Fit Line:	-0.00111
	Angle of Best Fit Line:	-0.06352
	Max Angular Difference:	**0.05**

Parrallelism Diameter 2

End 1:	Slope of Best Fit Line:	-0.00267
	Angle of Best Fit Line:	-0.15273
End 2:	Slope of Best Fit Line:	-0.00286
	Angle of Best Fit Line:	-0.16387
	Max Angular Difference:	**0.01**

Parallelism Tolerance Met? **YES**

Perpendicularity (Procedure P1) is met when the difference between max and min readings along each line divided by the diameter is ≤ 0.0043.

	Difference b/w max & min	Divide by Diameter	Meets Tolerance
End 1 Diam 1	0.0004	0.0002	**YES**
End 1 Diam 2	0.0049	0.0025	**YES**
End 2 Diam 1	0.0024	0.0012	**YES**
End 2 Diam 2	0.0054	0.0027	**YES**

Perpendicularity Tolerance Met? **YES**

PREPARING ROCK CORE AS CYLINDRICAL TEST SPECIMENS AND VERIFYING CONFORMANCE TO DIMENSIONAL AND SHAPE TOLERANCES (ASTM D4543)

1413 Topside Road, Louisville, TN 37777

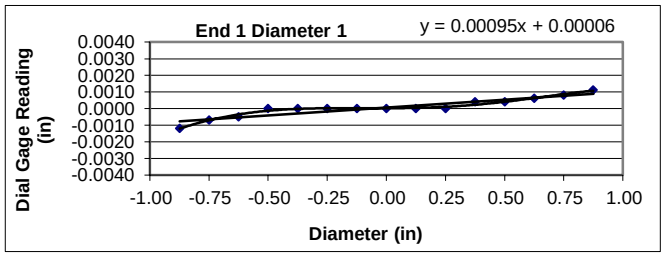
Project:	FS - 23 Mcfarland Road	**Diameter (in):**	1.98	**Date:**	2/23/2024
Project No.:	23430366	**Length (in):**	4.36	**Tested by:**	Ryan Skinner
Boring Id:	FS-23-B6	**Unit Weight (pcf):**	175.7	**Reviewed by:**	Tyler Copeman
Sample No.:	Run-02	**Moisture Content (%):**	0.1		
Depth (ft):	7.9 - 8.3				

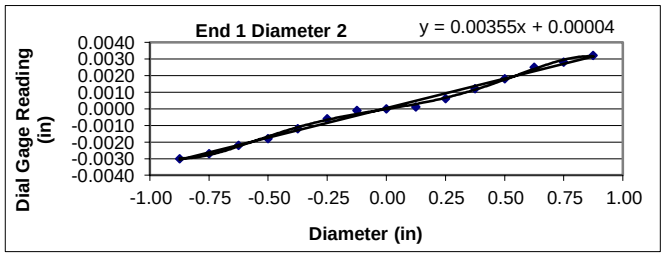
Deviation From Straightness (Procedure S1)

Is the maximum gap ≤ 0.02 in.? **YES** Straightness Tolerance Met? **YES**

End Flatness and Parallelism Readings (Procedure FP1)

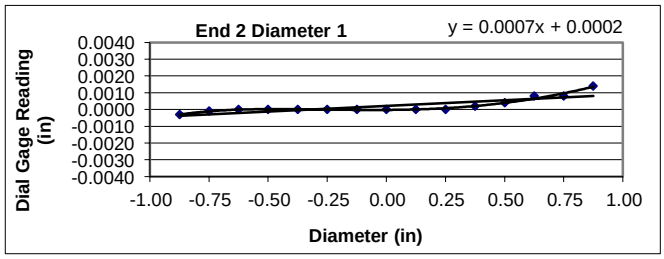
Position	End 1	End 1(90)	End 2	End 2(90)
- 7/8	-0.0012	-0.0030	-0.0003	-0.0009
- 6/8	-0.0007	-0.0027	-0.0001	-0.0006
- 5/8	-0.0005	-0.0022	0.0000	-0.0006
- 4/8	0.0000	-0.0018	0.0000	-0.0002
- 3/8	0.0000	-0.0012	0.0000	0.0000
- 2/8	0.0000	-0.0006	0.0000	0.0000
- 1/8	0.0000	-0.0001	0.0000	0.0000
0	0.0000	0.0000	0.0000	0.0000
1/8	0.0000	0.0001	0.0000	0.0000
2/8	0.0000	0.0006	0.0000	0.0003
3/8	0.0004	0.0012	0.0002	0.0003
4/8	0.0004	0.0018	0.0004	0.0007
5/8	0.0006	0.0025	0.0008	0.0009
6/8	0.0008	0.0028	0.0008	0.0011
7/8	0.0011	0.0032	0.0014	0.0012

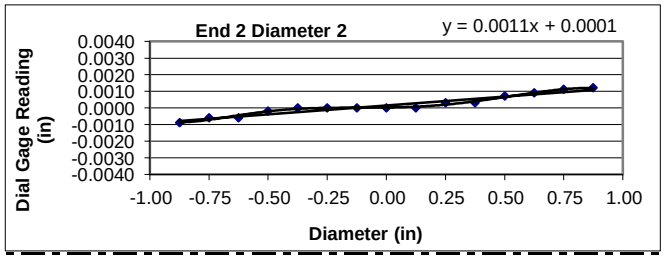




Flatness is met when the difference at any point between a smooth curve drawn through points and a visual best fit line is ≤ 0.001 in.

Flatness Tolerance Met? **YES**





Parallelism is met when the angular difference between best fit lines on opposing ends is ≤ 0.25°.

Parrallelism Diameter 1

End 1:	Slope of Best Fit Line:	0.00095
	Angle of Best Fit Line:	0.05468
End 2:	Slope of Best Fit Line:	0.00067
	Angle of Best Fit Line:	0.03847
	Max Angular Difference:	**0.02**

Parrallelism Diameter 2

End 1:	Slope of Best Fit Line:	0.00355
	Angle of Best Fit Line:	0.20315
End 2:	Slope of Best Fit Line:	0.00107
	Angle of Best Fit Line:	0.06139
	Max Angular Difference:	**0.14**

Parallelism Tolerance Met? **YES**

Perpendicularity (Procedure P1) is met when the difference between max and min readings along each line divided by the diameter is ≤ 0.0043.

	Difference b/w max & min	Divide by Diameter	Meets Tolerance
End 1 Diam 1	0.0023	0.0012	**YES**
End 1 Diam 2	0.0062	0.0031	**YES**
End 2 Diam 1	0.0017	0.0009	**YES**
End 2 Diam 2	0.0021	0.0011	**YES**

Perpendicularity Tolerance Met? **YES**

PREPARING ROCK CORE AS CYLINDRICAL TEST SPECIMENS AND VERIFYING CONFORMANCE TO DIMENSIONAL AND SHAPE TOLERANCES (ASTM D4543)

1413 Topside Road, Louisville, TN 37777

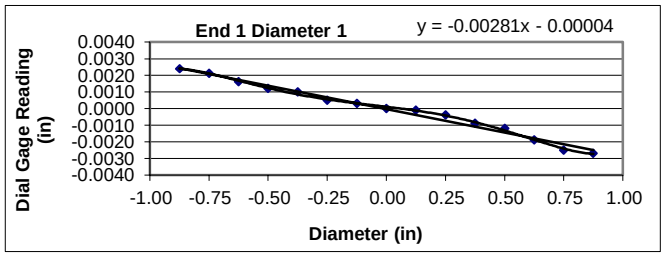
Project:	FS - 23 Mcfarland Road	**Diameter (in):**	1.98	**Date:**	2/23/2024
Project No.:	23430366	**Length (in):**	4.28	**Tested by:**	Ryan Skinner
Boring Id:	FS-23-B7	**Unit Weight (pcf):**	174.4	**Reviewed by:**	Tyler Copeman
Sample No.:	Run-01	**Moisture Content (%):**	0.1		
Depth (ft):	3.5 - 3.9				

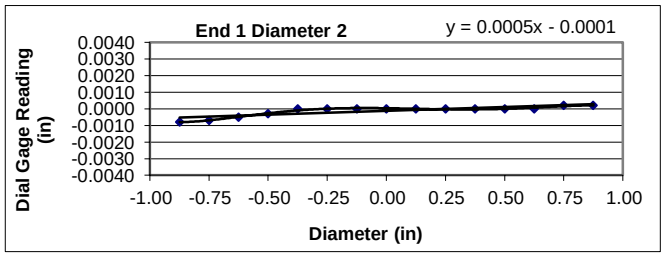
Deviation From Straightness (Procedure S1)

Is the maximum gap ≤ 0.02 in.? **YES** Straightness Tolerance Met? **YES**

End Flatness and Parallelism Readings (Procedure FP1)

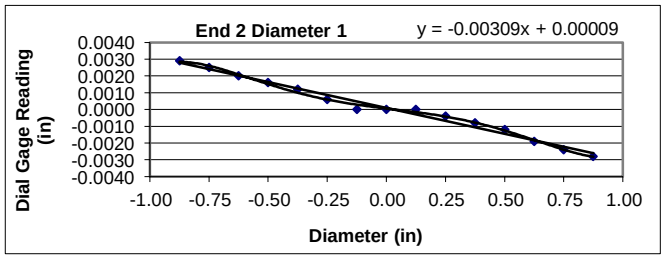
Position	End 1	End 1(90)	End 2	End 2(90)
- 7/8	0.0024	-0.0008	0.0029	-0.0023
- 6/8	0.0021	-0.0007	0.0025	-0.0018
- 5/8	0.0016	-0.0005	0.0020	-0.0013
- 4/8	0.0012	-0.0003	0.0016	-0.0008
- 3/8	0.0010	0.0000	0.0012	-0.0003
- 2/8	0.0005	0.0000	0.0006	0.0000
- 1/8	0.0003	0.0000	0.0000	0.0000
0	0.0000	0.0000	0.0000	0.0000
1/8	-0.0001	0.0000	0.0000	0.0003
2/8	-0.0004	0.0000	-0.0004	0.0008
3/8	-0.0009	0.0000	-0.0008	0.0011
4/8	-0.0012	0.0000	-0.0012	0.0015
5/8	-0.0019	0.0000	-0.0019	0.0019
6/8	-0.0025	0.0002	-0.0024	0.0021
7/8	-0.0027	0.0002	-0.0028	0.0025

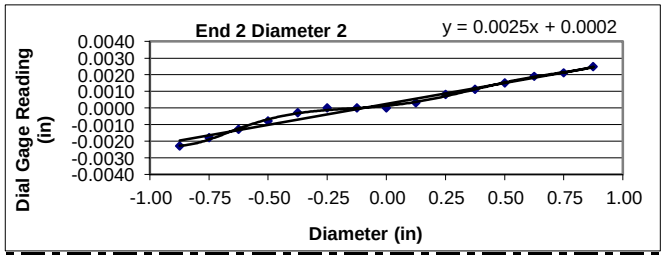




Flatness is met when the difference at any point between a smooth curve drawn through points and a visual best fit line is ≤ 0.001 in.

Flatness Tolerance Met? **YES**





Parallelism is met when the angular difference between best fit lines on opposing ends is ≤ 0.25°.

Parrallelism Diameter 1

End 1:	Slope of Best Fit Line:	-0.00281
	Angle of Best Fit Line:	-0.16092
End 2:	Slope of Best Fit Line:	-0.00309
	Angle of Best Fit Line:	-0.17680
	Max Angular Difference:	**0.02**

Parrallelism Diameter 2

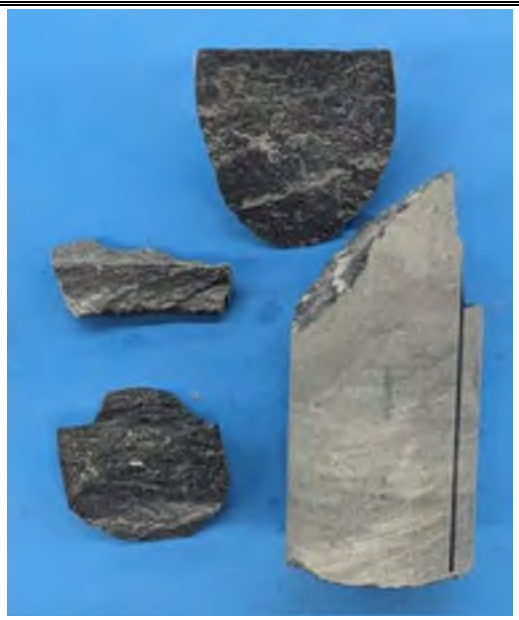
End 1:	Slope of Best Fit Line:	0.00046
	Angle of Best Fit Line:	0.02636
End 2:	Slope of Best Fit Line:	0.00252
	Angle of Best Fit Line:	0.14455
	Max Angular Difference:	**-0.12**

Parallelism Tolerance Met? **YES**

Perpendicularity (Procedure P1) is met when the difference between max and min readings along each line divided by the diameter is ≤ 0.0043.

	Difference b/w max & min	Divide by Diameter	Meets Tolerance
End 1 Diam 1	0.0051	0.0026	**YES**
End 1 Diam 2	0.0010	0.0005	**YES**
End 2 Diam 1	0.0057	0.0029	**YES**
End 2 Diam 2	0.0048	0.0024	**YES**

Perpendicularity Tolerance Met? **YES**



Date: 02/23/2024

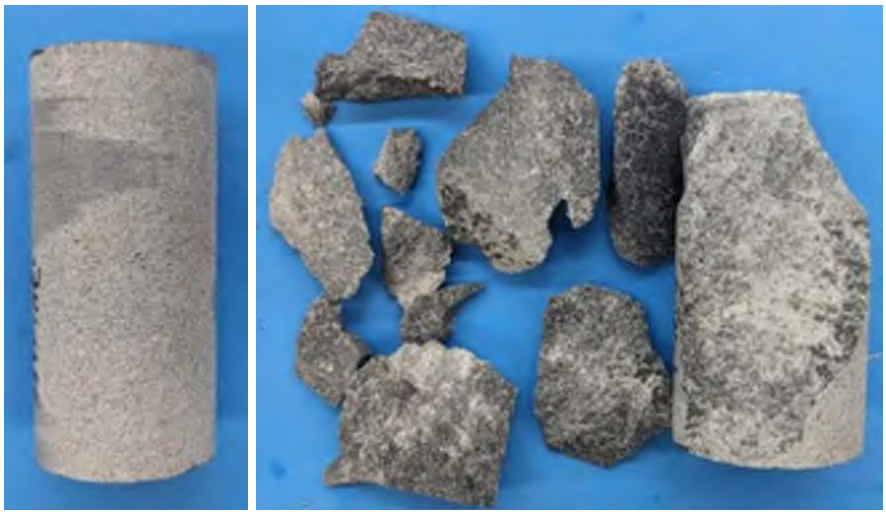
Photographer: Ryan Skinner

1	**Location / Orientation**	FS-23-B2, Run-03 (20.0′ – 20.4′)
	Remarks	Unconfined Compressive Strength of Rock Core Specimen Before/After (ASTM D7012 Method C)

Date: 02/23/2024

Photographer: Ryan Skinner

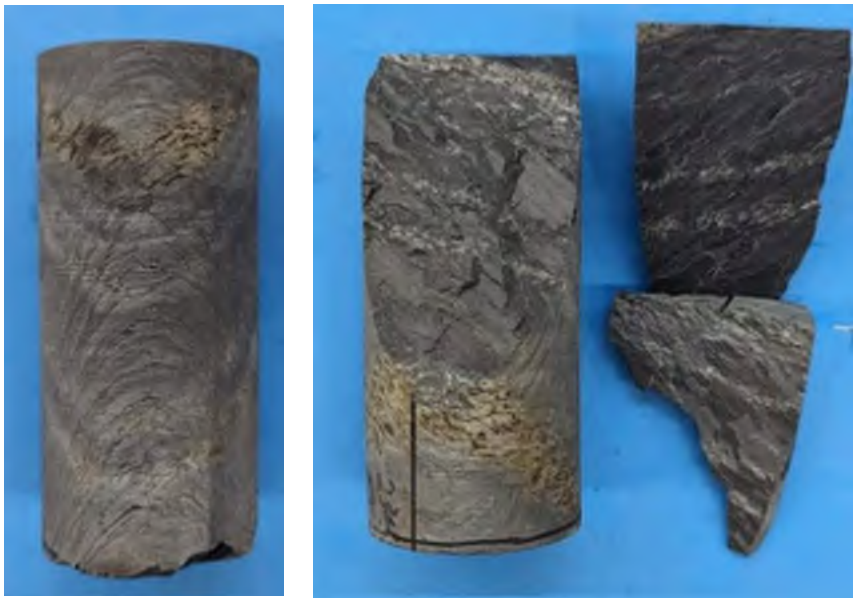
2	**Location / Orientation**	FS-23-B3, Run-01 (5.6′ – 6.0′)
	Remarks	Unconfined Compressive Strength of Rock Core Specimen Before/After (ASTM D7012 Method C)



Date: 02/23/2024

Photographer: Ryan Skinner

3	**Location / Orientation**	FS-23-B4, Run-02 (4.8′ – 5.2′)
	Remarks	Unconfined Compressive Strength of Rock Core Specimen Before/After (ASTM D7012 Method C)



Date: 02/23/2024

Photographer: Ryan Skinner

4	**Location / Orientation**	FS-23-B6, Run-02 (7.9′ – 8.3′)
	Remarks	Unconfined Compressive Strength of Rock Core Specimen Before/After (ASTM D7012 Method C)

Date: 02/23/2024

Photographer: Ryan Skinner

5	**Location / Orientation**	FS-23-B7, Run-01 (3.5′ – 3.9′)
	Remarks	Unconfined Compressive Strength of Rock Core Specimen Before/After (ASTM D7012 Method C)

STANDARD LABORATORIES, INC.

1530 North Cullen Ave Evansville, IN 47715

CERTIFICATE OF ANALYSIS

Date Received: 2/28/2024
Report Date: 4/1/2024

Customer Name: SM&E
Customer Address:

Sample ID:	44-2401805001
FS-23-BS APR RON-3 13.3-4	

Respectfully Submitted: kfest

Kate Fest

Sulfur %	0.39	% As Determined	D4239C	4/1/2024	twells

pH, Paste	8.38	UNITS	EPA-600/2-78-054 3.2.2	3/5/2024	twells

POTENTIAL ACIDITY	7.94	Ton CaCO3/T Ton	EPA-600/2-78-054 1.3.1	3/5/2024	CALCULATED
FIZZ RATE	1	RATING	EPA-600/2-78-054 3.2.3	3/5/2024	twells
NEUTRALIZATION POTENTIAL	56.35	Ton CaCO3/T Ton	EPA-600/2-78-054 3.2.3	3/5/2024	twells
NET NEUTRALIZATION POTENTIAL	48.41	Ton CaCO3/T Ton	EPA-600/2-78-054 1.3.1	3/5/2024	CALCULATED

Sulfur, Pyritic	0.254	% AS DETERMINED	ASTM D2492	3/8/2024	twells

N/D indicates result was under detectable range.

* Indicates test not covered by accreditation

** Tests performed by SL Evansville

Drilling Photos
Task 24 – FS 23 McFarland Road
Turtletown, Tennessee
S&ME Project No. 23430366

Date: 01/24/2024

Photographer: Pen Sibley

1	**Location / Orientation**	FS-23-B1
	Remarks	Before Drilling

Date: 01/24/2024

Photographer: Pen Sibley

2	**Location / Orientation**	FS-23-B1
	Remarks	Drilling Setup

Drilling Photos
Task 24 – FS 23 McFarland Road
Turtletown, Tennessee
S&ME Project No. 23430366

Date: 01/24/2024

Photographer: Pen Sibley

3	**Location / Orientation**	FS-23-B1
	Remarks	After Drilling

Date: 01/24/2024

Photographer: Ryan Skinner

4	**Location / Orientation**	FS-23-B2
	Remarks	Before Drilling

Drilling Photos
Task 24 – FS 23 McFarland Road
Turtletown, Tennessee
S&ME Project No. 23430366

Date: 01/24/2024

Photographer: Pen Sibley

5	**Location / Orientation**	FS-23-B2
	Remarks	Drilling Setup

Date: 01/24/2024

Photographer: Pen Sibley

6	**Location / Orientation**	FS-23-B2
	Remarks	After Drilling

Drilling Photos
Task 24 – FS 23 McFarland Road
Turtletown, Tennessee
S&ME Project No. 23430366

Date: 01/24/2024

Photographer: Pen Sibley

7	**Location / Orientation**	FS-23-B3
	Remarks	Before Drilling

Date: 01/24/2024

Photographer: Pen Sibley

8	**Location / Orientation**	FS-23-B3
	Remarks	Drilling Setup

Drilling Photos
Task 24 – FS 23 McFarland Road
Turtletown, Tennessee
S&ME Project No. 23430366

Date: 01/24/2024

Photographer: Pen Sibley

9	**Location / Orientation**	FS-23-B3
	Remarks	After Drilling

Date: 01/23/2024

Photographer: Pen Sibley

10	**Location / Orientation**	FS-23-B4
	Remarks	Before Drilling

Drilling Photos
Task 24 – FS 23 McFarland Road
Turtletown, Tennessee
S&ME Project No. 23430366

Date: 01/23/2024

Photographer: Pen Sibley

11	**Location / Orientation**	FS-23-B4
	Remarks	Drilling Setup

Date: 01/23/2024

Photographer: Pen Sibley

12	**Location / Orientation**	FS-23-B4
	Remarks	After Drilling

Drilling Photos
Task 24 – FS 23 McFarland Road
Turtletown, Tennessee
S&ME Project No. 23430366

Date: 01/23/2024

Photographer: Pen Sibley

13	**Location / Orientation**	FS-23-B5
	Remarks	Before Drilling

Date: 01/23/2024

Photographer: Pen Sibley

14	**Location / Orientation**	FS-23-B5
	Remarks	After Drilling

Drilling Photos
Task 24 – FS 23 McFarland Road
Turtletown, Tennessee
S&ME Project No. 23430366

Date: 01/23/2024

Photographer: Pen Sibley

15	**Location / Orientation**	FS-23-B6
	Remarks	Before Drilling

Date: 01/23/2024

Photographer: Pen Sibley

16	**Location / Orientation**	FS-23-B6
	Remarks	Drilling Setup

Drilling Photos
Task 24 – FS 23 McFarland Road
Turtletown, Tennessee
S&ME Project No. 23430366

Date: 01/23/2024

Photographer: Pen Sibley

17	**Location / Orientation**	FS-23-B6
	Remarks	After Drilling

Date: 01/23/2024

Photographer: Pen Sibley

18	**Location / Orientation**	FS-23-B7
	Remarks	Before Drilling

Drilling Photos
Task 24 – FS 23 McFarland Road
Turtletown, Tennessee
S&ME Project No. 23430366

Date: 01/23/2024

Photographer: Pen Sibley

19	**Location / Orientation**	FS-23-B7
	Remarks	After Drilling

Appendix C

- Computations

Seismic Design Parameters

Conterminous 48 States
2007 AASHTO Bridge Design Guidelines
AASHTO Spectrum for 7% PE in 75 years
Latitude = 35.171009
Longitude = -084.390216
Site Class B
Data are based on a 0.05 deg grid spacing.

Period (sec)	Sa (g)	
0.0	0.148	PGA - Site Class B
0.2	0.270	Ss - Site Class B
1.0	0.069	S1 - Site Class B

Conterminous 48 States
2007 AASHTO Bridge Design Guidelines
Spectral Response Accelerations SDs and SD1
Latitude = 35.171009
Longitude = -084.390216
As = FpgaPGA, SDs = FaSs, and SD1 = FvS1
Site Class C - Fpga = 1.20, Fa = 1.20, Fv = 1.70
Data are based on a 0.05 deg grid spacing.

Period (sec)	Sa (g)	
0.0	0.178	As - Site Class C
0.2	0.324	SDs - Site Class C
1.0	0.117	SD1 - Site Class C

McFarland Road (FS23) - P365 MP 9.245

Conterminous 48 States
2007 AASHTO Bridge Design Guidelines
AASHTO Spectrum for 7% PE in 75 years
Latitude = 35.168643
Longitude = -084.382688
Site Class B
Data are based on a 0.05 deg grid spacing.

Period (sec)	Sa (g)	
0.0	0.148	PGA - Site Class B
0.2	0.270	Ss - Site Class B
1.0	0.069	S1 - Site Class B

Conterminous 48 States
2007 AASHTO Bridge Design Guidelines
Spectral Response Accelerations SDs and SD1
Latitude = 35.168643
Longitude = -084.382688
As = FpgaPGA, SDs = FaSs, and SD1 = FvS1
Site Class C - Fpga = 1.20, Fa = 1.20, Fv = 1.70
Data are based on a 0.05 deg grid spacing.

Period (sec)	Sa (g)	
0.0	0.178	As - Site Class C
0.2	0.323	SDs - Site Class C
1.0	0.117	SD1 - Site Class C

McFarland Road (FS23) - P370 MP 10.189

Conterminous 48 States
2007 AASHTO Bridge Design Guidelines
AASHTO Spectrum for 7% PE in 75 years
Latitude = 35.166176
Longitude = -084.381200
Site Class B
Data are based on a 0.05 deg grid spacing.

Period (sec)	Sa (g)	
0.0	0.148	PGA - Site Class B
0.2	0.269	Ss - Site Class B
1.0	0.069	S1 - Site Class B

Conterminous 48 States
2007 AASHTO Bridge Design Guidelines
Spectral Response Accelerations SDs and SD1
Latitude = 35.166176
Longitude = -084.381200
As = FpgaPGA, SDs = FaSs, and SD1 = FvS1
Site Class C - Fpga = 1.20, Fa = 1.20, Fv = 1.70
Data are based on a 0.05 deg grid spacing.

Period (sec)	Sa (g)	
0.0	0.177	As - Site Class C
0.2	0.323	SDs - Site Class C
1.0	0.117	SD1 - Site Class C

McFarland Road (FS23) - P371 MP 10.378

The basis of classification shall include social/survival and security/defense requirements. In classifying a bridge, consideration should be given to possible future changes in conditions and requirements.

3.10.6—Seismic Performance Zones

Each bridge shall be assigned to one of the four seismic zones in accordance with Table 3.10.6-1 using the value of S_{D1} given by Eq. 3.10.4.2-6.

Table 3.10.6-1—Seismic Zones

Acceleration Coefficient, S_{D1}	Seismic Zone
$S_{D1} \leq 0.15$	1
$0.15 < S_{D1} \leq 0.30$	2
$0.30 < S_{D1} \leq 0.50$	3
$0.50 < S_{D1}$	4

C3.10.6

These seismic zones reflect the variation in seismic risk across the country and are used to permit different requirements for methods of analysis, minimum support lengths, column design details, and foundation and abutment design procedures.

3.10.7—Response Modification Factors

3.10.7.1—General

To apply the response modification factors specified herein, the structural details shall satisfy the provisions of Articles 5.10.2.2 and 5.11.

Except as noted herein, seismic design force effects for substructures and the connections between parts of structures, listed in Table 3.10.7.1-2, shall be determined by dividing the force effects resulting from elastic analysis by the appropriate response modification factor, R, as specified in Tables 3.10.7.1-1 and 3.10.7.1-2, respectively.

As an alternative to the use of the R-factors, specified in Table 3.10.7.1-2 for connections, monolithic joints between structural members and/or structures, such as a column-to-footing connection, may be designed to transmit the maximum force effects that can be developed by the inelastic hinging of the column or multicolumn bent they connect as specified in Article 3.10.9.4.3.

If an inelastic time history method of analysis is used, the response modification factor, R, shall be taken as 1.0 for all substructure and connections.

C3.10.7.1

These Specifications recognize that it is uneconomical to design a bridge to resist large earthquakes elastically. Columns are assumed to deform inelastically where seismic forces exceed their design level, which is established by dividing the elastically computed force effects by the appropriate R-factor.

R-factors for connections are smaller than those for substructure members in order to preserve the integrity of the bridge under these extreme loads. For expansion joints within the superstructure and connections between the superstructure and abutment, the application of the R-factor results in force effect magnification. Connections that transfer forces from one part of a structure to another include, but are not limited to, fixed bearings, expansion bearings with either restrainers, STUs, or dampers, and shear keys. For one-directional bearings, these R-factors are used in the restrained direction only. In general, forces determined on the basis of plastic hinging will be less than those given by using Table 3.10.7.1-2, resulting in a more economical design.

Table 3.10.7.1-1—Response Modification Factors—Substructures

Substructure	Operational Category		
	Critical	Essential	Other
Wall-type piers—larger dimension	1.5	1.5	2.0
Reinforced concrete pile bents			
• Vertical piles only	1.5	2.0	3.0
• With batter piles	1.5	1.5	2.0
Single columns	1.5	2.0	3.0
Steel or composite steel and concrete pile bents			
• Vertical pile only	1.5	3.5	5.0
• With batter piles	1.5	2.0	3.0
Multiple column bents	1.5	3.5	5.0

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Table 3.10.3.1-1—Site Class Definitions

Site Class	Soil Type and Profile
A	Hard rock with measured shear wave velocity, $\bar{v}_s > 5{,}000$ ft/s
B	Rock with 2,500 ft/sec < $\bar{v}_s$ < 5,000 ft/s
C	Very dense soil and soil rock with 1,200 ft/sec < $\bar{v}_s$ < 2,500 ft/s, or with either $\bar{N}$ > 50 blows/ft, or $\bar{s}_u$ > 2.0 ksf
D	Stiff soil with 600 ft/s < $\bar{v}_s$ < 1,200 ft/s, or with either 15 < $\bar{N}$ < 50 blows/ft, or 1.0 < $\bar{s}_u$ < 2.0 ksf
E	Soil profile with $\bar{v}_s$ < 600 ft/s or with either $\bar{N}$ < 15 blows/ft or $\bar{s}_u$ < 1.0 ksf, or any profile with more than 10.0 ft of soft clay defined as soil with PI > 20, w > 40 percent and $\bar{s}_u$ < 0.5 ksf
F	Soils requiring site-specific evaluations, such as: • Peats or highly organic clays (H > 10.0 ft of peat or highly organic clay where H = thickness of soil) • Very high plasticity clays (H > 25.0 ft with PI > 75) • Very thick soft/medium stiff clays (H >120 ft)

Exceptions: Where the soil properties are not known in sufficient detail to determine the site class, a site investigation shall be undertaken sufficient to determine the site class. Site classes E or F should not be assumed unless the authority having jurisdiction determines that site classes E or F could be present at the site or in the event that site classes E or F are established by geotechnical data.

where:

$\bar{v}_s$ = average shear wave velocity for the upper 100 ft of the soil profile

$\bar{N}$ = average Standard Penetration Test (SPT) blow count (blows/ft) (ASTM D1586) for the upper 100 ft of the soil profile

$\bar{s}_u$ = average undrained shear strength in ksf (ASTM D2166 or ASTM D2850) for the upper 100 ft of the soil profile

PI = plasticity index (ASTM D4318)

w = moisture content (ASTM D2216)

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Project: **McFarland Road FS 23 - P365: MP 9.245**

	Boring No.:	**FS 23 - B1**	**FS 23 - B2**						
Depth	Depth (d_i)	N	N	N	N	N	N	N_{AVG}	d_i/N
0.1	0.1	100	100					100	0.00
2	1.9	19	22					21	0.09
4	2	7	10					9	0.24
6	2	11	30					21	0.10
10	4	25	100					63	0.06
15	5	31	100					66	0.08
17.5	2.5	28	100					64	0.04
20	2.5	22	100					61	0.04
25	5	20	100					60	0.08
30	5	22	100					61	0.08
35	5	24	100					62	0.08
40	5	100	100					100	0.05
45	5	100	100					100	0.05
50	5	100	100					100	0.05
55	5	100	100					100	0.05
60	5	100	100					100	0.05
65	5	100	100					100	0.05
70	5	100	100					100	0.05
75	5	100	100					100	0.05
80	5	100	100					100	0.05
85	5	100	100					100	0.05
90	5	100	100					100	0.05
95	5	100	100					100	0.05
100	5	100	100					100	0.05
Sum	100							1,886	1.54

N_{bar}= 65 Seismic Site Class = C

Project: **McFarland Road FS 23 - P370: MP 10.189**

	Boring No.:	**FS 23 - B3**	**FS 23 - B4**	**FS 23 - B5**					
Depth	Depth (d_i)	N	N	N	N	N	N	N_{AVG}	d_i/N
0.1	0.1	100	100	100				100	0.00
2	1.9	9	100	22				44	0.04
4	2	5	100	100				68	0.03
6	2	100	100	100				100	0.02
11	5	100	100	100				100	0.05
16	5	100	100	100				100	0.05
21	5	100	100	100				100	0.05
26	5	100	100	100				100	0.05
31	5	100	100	100				100	0.05
36	5	100	100	100				100	0.05
41	5	100	100	100				100	0.05
46	5	100	100	100				100	0.05
51	5	100	100	100				100	0.05
56	5	100	100	100				100	0.05
61	5	100	100	100				100	0.05
66	5	100	100	100				100	0.05
71	5	100	100	100				100	0.05
76	5	100	100	100				100	0.05
81	5	100	100	100				100	0.05
86	5	100	100	100				100	0.05
91	5	100	100	100				100	0.05
100	9	100	100	100				100	0.09
Sum	100							2,112	1.03

N_{bar}= 97 Seismic Site Class = C

Project: **McFarland Road FS 23 - P371: MP 10.378**

	Boring No.:	**FS 23 - B6**	**FS 23 - B7**						
Depth	Depth (d_i)	N	N	N	N	N	N	N_{AVG}	d_i/N
0.1	0.1	100	100					100	0.00
2	1.9	27	23					25	0.08
5	3	100	100					100	0.03
10	5	100	100					100	0.05
15	5	100	100					100	0.05
20	5	100	100					100	0.05
25	5	100	100					100	0.05
30	5	100	100					100	0.05
35	5	100	100					100	0.05
40	5	100	100					100	0.05
45	5	100	100					100	0.05
50	5	100	100					100	0.05
55	5	100	100					100	0.05
60	5	100	100					100	0.05
65	5	100	100					100	0.05
70	5	100	100					100	0.05
75	5	100	100					100	0.05
80	5	100	100					100	0.05
85	5	100	100					100	0.05
90	5	100	100					100	0.05
95	5	100	100					100	0.05
99	4	100	100					100	0.04
100	1	100	100					100	0.01
Sum	100							2,225	1.06

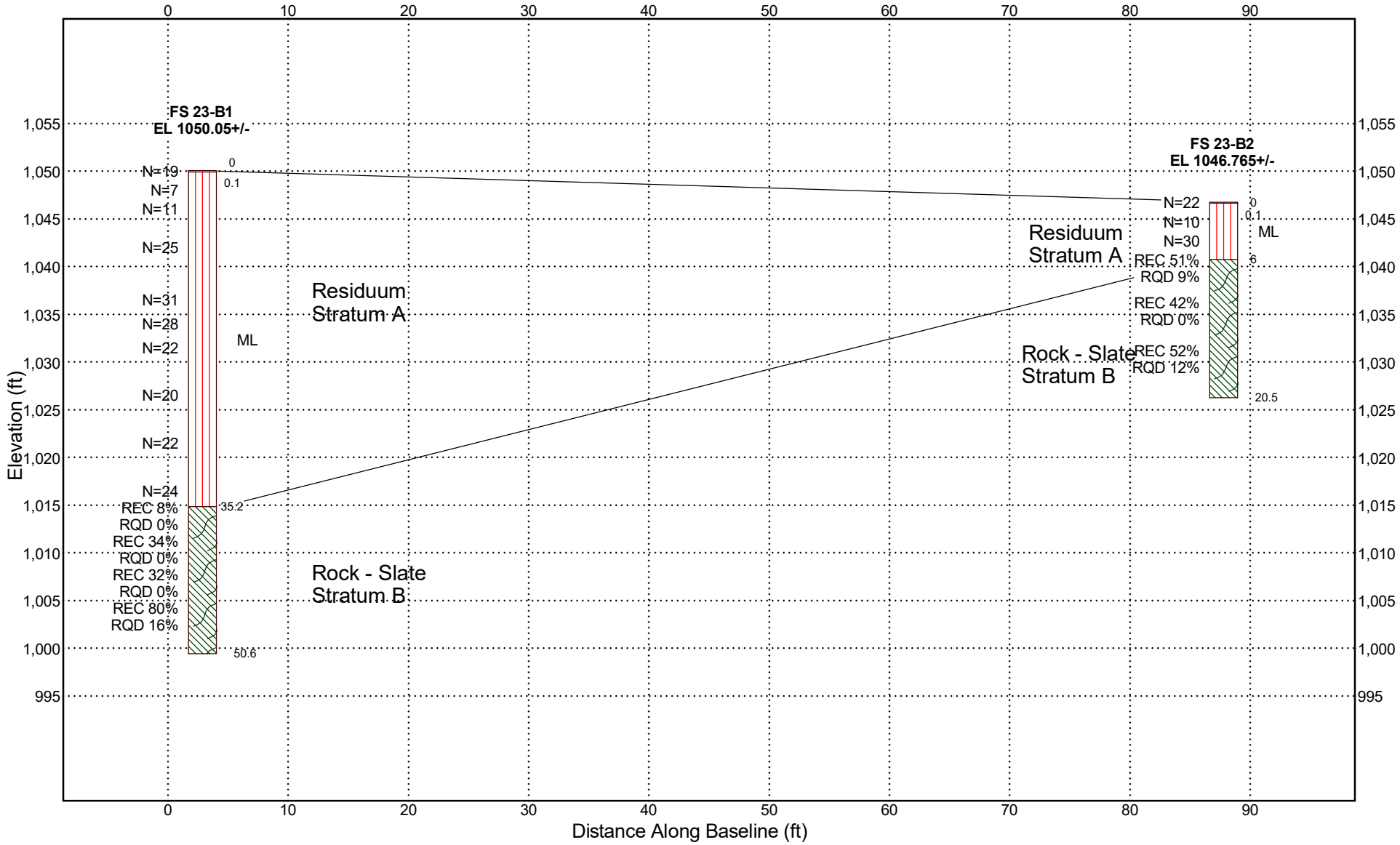
N_{bar}= 95 Seismic Site Class = C

MP 9.245, MP 10.189 and MP 10.378
Soil Profiles

JMT
40 Wight Avenue
Hunt Valley, MD 21030

ESTIMATED SUBSURFACE PROFILE
McFarland Rd. (FS 23) MP 9.245

CLIENT Federal highway Administration Eastern Federal Lands Highway Division
PROJECT NUMBER 19-01472-007
PROJECT NAME McFarland Road (FS 23)
PROJECT LOCATION Polk County, Tennessee

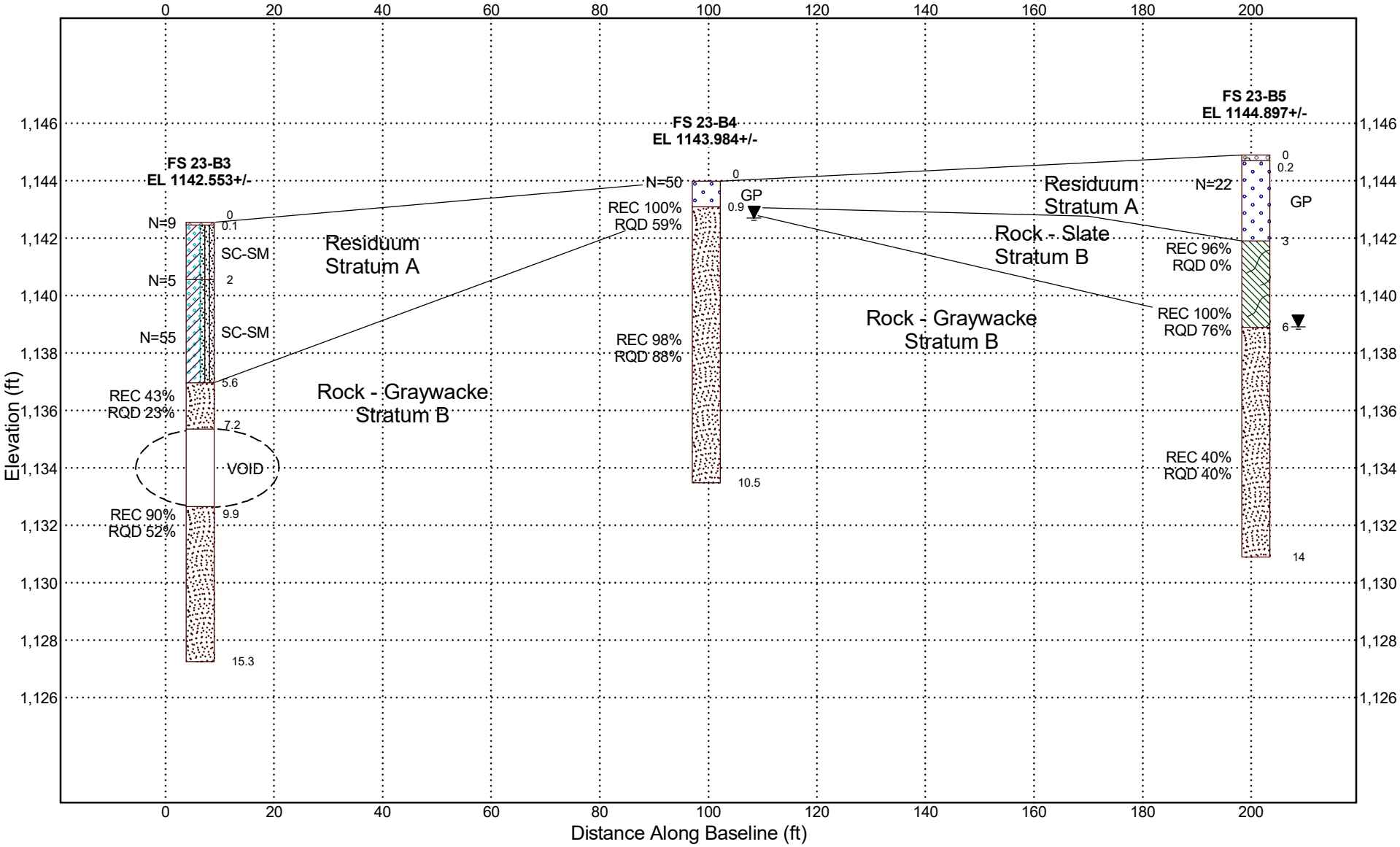


8.5 X 11 WITH JMT BORDER MCFARLAND ROAD.GPJ JMT STANDARD DATA TEMPLATE 02-13-14.GDT 4/13/24

JMT
40 Wight Avenue
Hunt Valley, MD 21030

ESTIMATED SUBSURFACE PROFILE
McFarland Rd. (FS 23) MP 10.189

CLIENT Federal highway Administration Eastern Federal Lands Highway Division
PROJECT NUMBER 19-01472-007
PROJECT NAME McFarland Road (FS 23)
PROJECT LOCATION Polk County, Tennessee

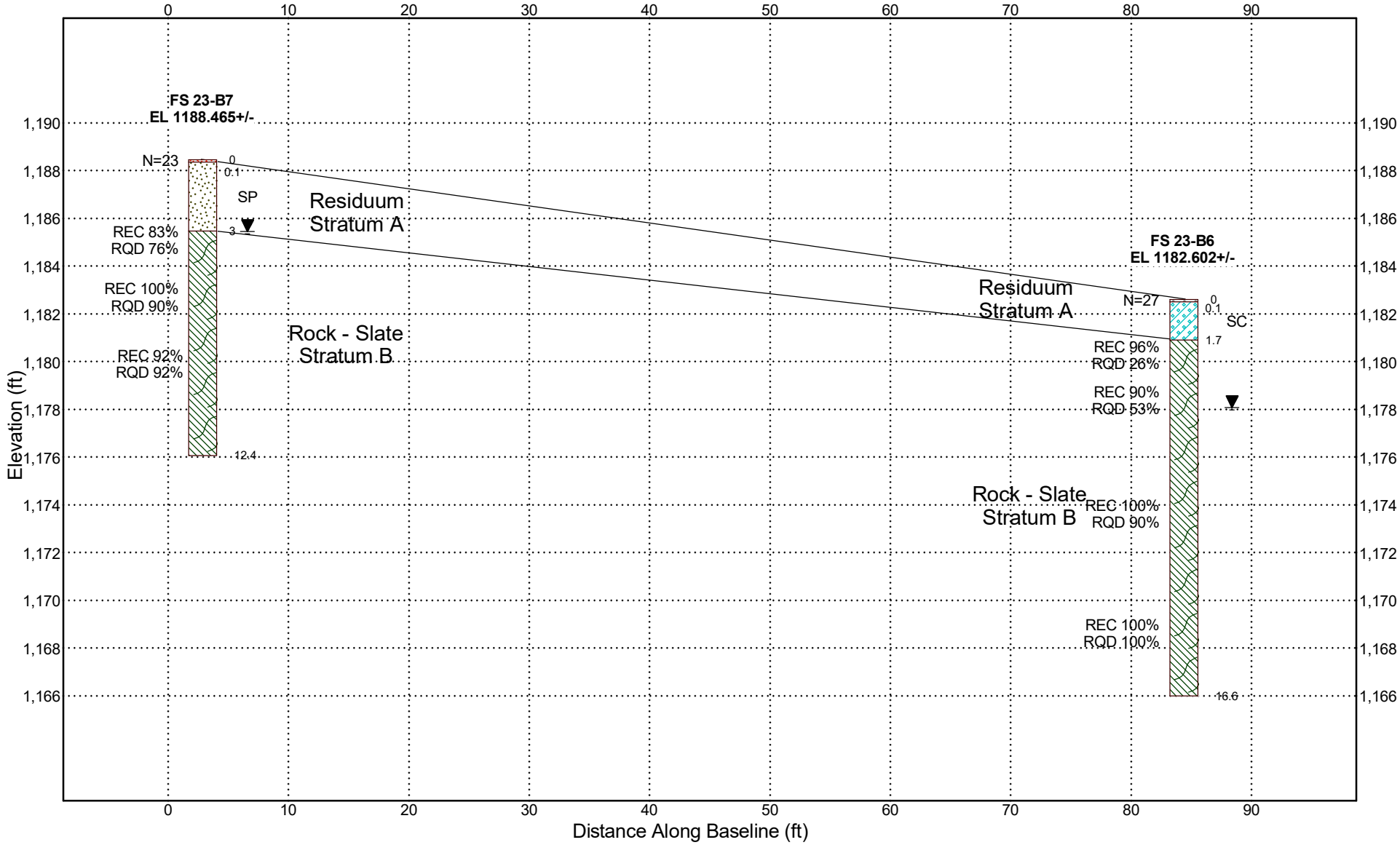


8.5 X 11 WITH JMT BORDER MCFARLAND ROAD.GPJ JMT STANDARD DATA TEMPLATE 02-13-14.GDT 4/13/24

JMT
40 Wight Avenue
Hunt Valley, MD 21030

ESTIMATED SUBSURFACE PROFILE
McFarland Rd. (FS 23) MP 10.378

CLIENT Federal highway Administration Eastern Federal Lands Highway Division
PROJECT NUMBER 19-01472-007
PROJECT NAME McFarland Road (FS 23)
PROJECT LOCATION Polk County, Tennessee



8.5 X 11 WITH JMT BORDER MCFARLAND ROAD.GPJ JMT STANDARD DATA TEMPLATE 02-13-14.GDT 4/13/24

MP 9.245
Footing on Residuum
Factored Bearing Resistance

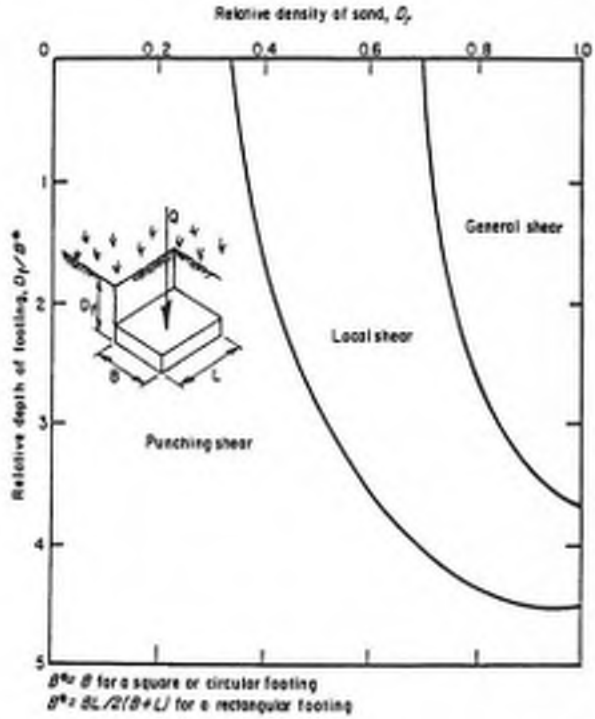


Figure C10.6.3.1.2b-1—Modes of Bearing Capacity Failure for Footings in Sand

10.6.3.1.2c—Considerations for Footings on Slopes

For footings constructed on or adjacent to slopes, the nominal bearing resistance shall be determined using a reduction coefficient (RC_{BC}) as presented in Tables 10.6.3.1.2c-1 and 10.6.3.1.2c-2. The reduction coefficient should be applied directly to the nominal bearing resistance calculated from Eq.10.6.3.1.2a-1 for footings on level ground and supported on the same foundation soil conditions.

The nominal resistance of footings on or adjacent to slopes shall be taken as:

$$q_{n\text{-}sloping\ ground} = RC_{BC}q_n = RC_{BC}\left(cN_c + 0.5\gamma BN_\gamma\right) \quad (10.6.3.1.2c\text{-}1)$$

= 0.118(0+0.5*125 pcf*5'*41.1)

where: = 1,515, say 1,500 psf or 1.5 ksf

$q_{n\text{-}sloping\ ground}$ = the nominal footing bearing resistance considering the effect of sloping ground (ksf)

RC_{BC} = reduction coefficient for bearing resistance due to slope effects (dim)

and other variables are as defined in Article 10.6.3.1.2a and Figure 10.6.3.1.2c-1. The bearing capacity factors N_c and N_γ are obtained in accordance with Article 10.6.3.1.2a.

Reduction coefficients (RC_{BC}) should be determined using the definitions illustrated in Figure 10.6.3.1.2c-1

C10.6.3.1.2c

A rational approach for determining a modified bearing resistance for footings on or adjacent to a slope is presented in Leshchinsky (2015) and Leshchinsky and Xie (2016). These methods are considered valid and applicable to structure foundations in addition to the MSE retaining wall example presented in the reference papers. The reduction coefficients provided in Tables 10.6.3.1.2c-1 and 10.6.3.1.2c-2 are modified and reconfigured by the author of the cited papers to allow for more convenient use in practice. See the original papers for the complete tabulation of reduction coefficient values.

The reduction coefficients are applicable to purely cohesive, purely cohesionless and c-ϕ soils. The RC_{BC} factors are based on no footing embedment for footings either on or adjacent to slopes and may be conservative for deep footing embedment depths.

Limit analysis, or limit equilibrium analysis, should be considered to estimate the nominal bearing resistance of footings on or adjacent to slopes composed of soils and/or site conditions that are not consistent with the parameters and conditions described in the reference documents (i.e. embedment >0, layered soils, steeper slopes).

The schematic shown in Figure 10.6.3.1.2c-1 is provided only for illustrating and defining the terms used in the design equations and tables. This figure should not be used as the basis for locating footings on slopes regarding embedment depth and setback.

Factored Bearing Resistance = 0.45 * 1500 psf = 675 psf

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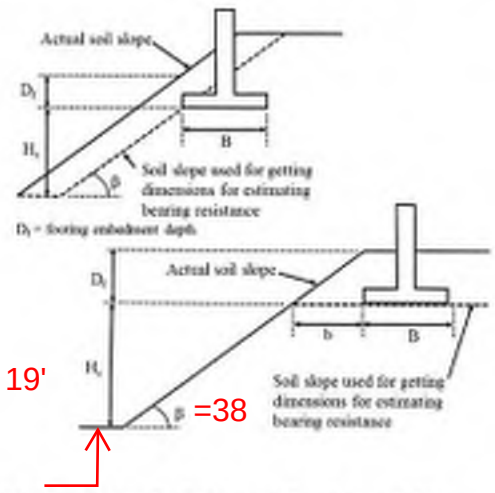
for footings on or adjacent to slopes. Use linear interpolation to obtain reduction coefficients for values not provided. The slope stability factor, N_s, in Tables 10.6.3.1.2c-1 and 10.6.3.1.2c-2 shall be taken as:

$$N_s = \frac{\gamma H_s}{c} \qquad (10.6.3.1.2c\text{-}2)$$

where:

N_s = slope stability factor (dim)
H_s = height of sloping ground surface below bottom of footing (ft)

and other variables are as defined in Article 10.6.3.1.2a.



b= 4' Min
B= 5' Min

b/B= 4/5 = 0.8

B/H = 5/19 = 0.26

Figure 10.6.3.1.2c-1—Definition of Footing and Slope Geometric Parameters for Determination of RC_{BC}

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- Reduction Coefficients (RC_{BC}) for Footings Placed Adjacent to Slopes Composed - Purely Cohesionless Soils ($c'=0$)

phi	34 deg
B/H	0.26
b/B	0.8
β	38 deg
c	0

phi	B/H	b/B	β	RC_{BC}	phi	B/H	b/B	β	RC_{BC}
30	0.2	0.5	30	0.21	40	0.2	0.5	30	0.25
30	0.2	0.5	40	0	40	0.2	0.5	40	0.13
30	0.2	0.5	38	0.042	40	0.2	0.5	38	0.154
30	0.2	1.25	30	0.38	40	0.2	1.25	30	0.39
30	0.2	1.25	40	0	40	0.2	1.25	40	0.25
30	0.2	1.25	38	0.076	40	0.2	1.25	38	0.278
30	0.2	0.5	38	0.042	40	0.2	0.5	38	0.154
30	0.2	1.25	38	0.076	40	0.2	1.25	38	0.278
30	0.2	0.8	38	0.0556	40	0.2	0.8	38	0.2036
30	0.5	0.5	30	0.24	40	0.5	0.5	30	0.25
30	0.5	0.5	40	0	40	0.5	0.5	40	0.09
30	0.5	0.5	38	0.048	40	0.5	0.5	38	0.122
30	0.5	1.25	30	0.45	40	0.5	1.25	30	0.4
30	0.5	1.25	40	0	40	0.5	1.25	40	0.18
30	0.5	1.25	38	0.09	40	0.5	1.25	38	0.224
30	0.5	0.5	38	0.048	40	0.5	0.5	38	0.122
30	0.5	1.25	38	0.09	40	0.5	1.25	38	0.4
30	0.5	0.8	38	0.0648	40	0.5	0.8	38	0.2332
30	0.2	0.8	38	0.0556	40	0.2	0.8	38	0.2036
30	0.5	0.8	38	0.0648	40	0.5	0.8	38	0.2332
30	0.26	0.8	38	0.05744	40	0.26	0.8	38	0.20952
30	0.26	0.8	38	0.05744					
40	0.26	0.8	38	0.20952					
34	0.26	0.8	38	**0.118**					

Table 10.6.3.1.2c-2 (cont.)— Reduction Coefficients (RC_{BC}) for Footings Placed Adjacent to Slopes Composed of either Purely Cohesive Soils, (ϕ = 0); Purely Cohesionless Soils (c'=0); or Soils with both Cohesive and Cohesionless Strength Components

			β=10°				β=20°				β=30°				β=40°			
			Ns				*Ns*				*Ns*				*Ns*			
φ (°)	***B/H***	***b/B***	**0**	**2**	**4**	***c'*=0**	**0**	**2**	**4**	***c'*=0**	**0**	**2**	**4**	***c'*=0**	**0**	**2**	**4**	***c'*=0**
30	0.2	0	0.93	0.92	0.91	0.76	0.65	0.64	0.63	0.39	0.51	0.50	0.48	0.11	0.40	0.37	0.36	0.00
		0.5	0.74	0.81	0.80	0.75	0.70	0.66	0.65	0.50	0.57	0.52	0.49	0.21	0.47	0.42	0.39	0.00
		1.25	0.78	0.85	0.86	0.86	0.74	0.73	0.72	0.72	0.63	0.60	0.59	0.38	0.54	0.50	0.47	0.00
		2.5	0.84	0.92	0.93	0.99	0.81	0.82	0.83	0.94	0.72	0.73	0.74	0.74	0.64	0.62	0.61	0.00
		5	0.95	1.00	1.00	1.00	0.93	0.98	1.00	1.00	0.88	0.95	1.00	0.97	0.80	0.85	0.87	0.00
		10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
	0.5	0	0.79	0.79	0.78	0.70	0.63	0.59	0.55	0.36	0.50	0.43	0.39	0.13	0.39	0.32	0.27	0.00
		0.5	0.76	0.87	0.87	0.74	0.72	0.71	0.70	0.51	0.58	0.56	0.54	0.24	0.49	0.46	0.43	0.00
		1.25	0.79	0.85	0.92	0.87	0.75	0.73	0.76	0.72	0.63	0.62	0.61	0.45	0.54	0.52	0.50	0.00
		2.5	0.87	0.91	1.00	0.99	0.84	0.85	0.90	0.98	0.74	0.78	0.80	0.80	0.67	0.70	0.71	0.00
		5	0.97	1.00	1.00	1.00	0.95	1.00	1.00	1.00	0.90	1.00	1.00	1.00	0.85	0.94	0.98	0.00
		10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
	1	0	0.79	0.75	0.73	0.67	0.63	0.53	0.49	0.41	0.55	0.41	0.35	0.24	0.48	0.33	0.26	0.00
		0.5	0.78	0.87	0.89	0.74	0.75	0.74	0.74	0.51	0.64	0.62	0.60	0.35	0.59	0.56	0.54	0.00
		1.25	0.81	0.90	0.91	0.88	0.78	0.78	0.78	0.72	0.68	0.67	0.66	0.58	0.64	0.62	0.61	0.00
		2.5	0.88	0.99	1.00	0.96	0.85	0.90	0.92	0.95	0.78	0.81	0.84	0.88	0.75	0.78	0.80	0.00
		5	0.97	1.00	1.00	1.00	0.96	1.00	1.00	1.00	0.92	1.00	1.00	1.00	0.89	0.98	1.00	0.00
		10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
	2	0	0.88	0.88	0.87	0.65	0.87	0.85	0.83	0.48	0.85	0.82	0.80	0.38	0.83	0.80	0.76	0.00
		0.5	0.89	0.91	0.91	0.75	0.89	0.89	0.87	0.58	0.88	0.86	0.84	0.51	0.87	0.85	0.82	0.00
		1.25	0.90	0.92	0.93	0.88	0.90	0.90	0.90	0.75	0.89	0.87	0.87	0.70	0.89	0.87	0.86	0.00
		2.5	0.97	1.00	1.00	1.00	0.96	0.97	0.98	0.98	0.92	0.94	0.96	0.95	0.91	0.92	0.94	0.00
		5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
		10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
40	0.2	0	0.69	0.69	0.69	0.78	0.51	0.48	0.47	0.37	0.37	0.33	0.30	0.16	0.27	0.23	0.20	0.05
		0.5	0.65	0.73	0.71	0.74	0.60	0.55	0.53	0.38	0.64	0.38	0.35	0.25	0.34	0.29	0.25	0.13
		1.25	0.68	0.77	0.75	0.86	0.63	0.60	0.58	0.55	0.74	0.44	0.42	0.39	0.39	0.34	0.31	0.25
		2.5	0.72	0.83	0.84	1.00	0.68	0.68	0.68	0.76	0.87	0.53	0.53	0.62	0.45	0.43	0.41	0.48
		5	0.80	0.93	0.95	1.00	0.76	0.82	0.85	1.00	1.00	0.72	0.76	1.00	0.57	0.61	0.63	0.94
		10	0.94	1.00	1.00	1.00	0.91	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.76	0.93	1.00	1.00
	0.5	0	0.67	0.69	0.67	0.69	0.50	0.45	0.43	0.35	0.36	0.30	0.26	0.17	0.27	0.20	0.17	0.07
		0.5	0.68	0.81	0.81	0.73	0.63	0.62	0.61	0.46	0.47	0.44	0.41	0.25	0.39	0.35	0.32	0.09
		1.25	0.70	0.82	0.84	0.85	0.65	0.65	0.66	0.60	0.51	0.49	0.47	0.40	0.43	0.41	0.39	0.18
		2.5	0.76	0.92	0.96	1.00	0.72	0.77	0.80	0.81	0.59	0.62	0.63	0.60	0.54	0.56	0.56	0.37
		5	0.84	1.00	1.00	1.00	0.81	0.91	0.94	1.00	0.71	0.82	0.88	1.00	0.67	0.77	0.83	0.84
		10	0.96	1.00	1.00	1.00	0.94	1.00	1.00	1.00	0.89	1.00	1.00	1.00	0.86	1.00	1.00	1.00
	1	0	0.69	0.64	0.62	0.70	0.63	0.48	0.43	0.45	0.58	0.39	0.33	0.32	0.54	0.33	0.27	0.24
		0.5	0.77	0.81	0.82	0.74	0.75	0.73	0.72	0.49	0.71	0.66	0.62	0.38	0.68	0.62	0.57	0.30
		1.25	0.78	0.84	0.85	0.84	0.77	0.76	0.75	0.64	0.73	0.69	0.66	0.55	0.71	0.66	0.63	0.48
		2.5	0.83	0.92	0.95	1.00	0.81	0.85	0.87	0.85	0.76	0.78	0.79	0.76	0.75	0.76	0.77	0.72
		5	0.89	1.00	1.00	1.00	0.87	0.95	0.98	1.00	0.80	0.90	0.95	1.00	0.80	0.89	0.94	1.00
		10	0.98	1.00	1.00	1.00	0.97	1.00	1.00	1.00	0.94	1.00	1.00	1.00	0.93	1.00	1.00	1.00
	2	0	0.93	0.92	0.89	0.45	0.92	0.90	0.87	0.60	0.91	0.88	0.84	0.53	0.89	0.85	0.81	0.47
		0.5	0.93	0.95	0.93	0.76	0.93	0.92	0.90	0.65	0.92	0.89	0.87	0.64	0.92	0.89	0.86	0.60
		1.25	0.93	0.95	0.94	0.86	0.93	0.93	0.92	0.78	0.93	0.91	0.89	0.74	0.93	0.90	0.88	0.74
		2.5	0.94	0.99	1.00	1.00	0.94	0.98	0.98	0.92	0.94	0.97	0.97	0.87	0.94	0.96	0.96	0.88
		5	0.95	1.00	1.00	1.00	0.96	1.00	1.00	1.00	0.98	1.00	1.00	1.00	0.96	1.00	1.00	1.00
		10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	1.00

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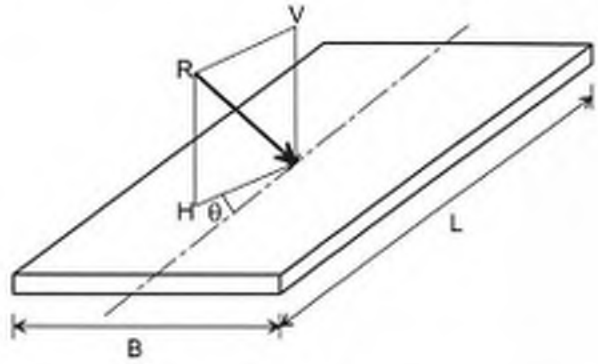

Figure C10.6.3.1.2a-1—Inclined Loading Conventions

Table 10.6.3.1.2a-1—Bearing Capacity Factors N_c (Prandtl, 1921), N_q (Reissner, 1924), and N_γ (Vesic, 1975)

ϕ_f	N_c	N_q	N_γ	ϕ_f	N_c	N_q	N_γ
0	5.14	1.0	0.0	23	18.1	8.7	8.2
1	5.4	1.1	0.1	24	19.3	9.6	9.4
2	5.6	1.2	0.2	25	20.7	10.7	10.9
3	5.9	1.3	0.2	26	22.3	11.9	12.5
4	6.2	1.4	0.3	27	23.9	13.2	14.5
5	6.5	1.6	0.5	28	25.8	14.7	16.7
6	6.8	1.7	0.6	29	27.9	16.4	19.3
7	7.2	1.9	0.7	30	30.1	18.4	22.4
8	7.5	2.1	0.9	31	32.7	20.6	26.0
9	7.9	2.3	1.0	32	35.5	23.2	30.2
10	8.4	2.5	1.2	33	38.6	26.1	35.2
11	8.8	2.7	1.4	34	42.2	29.4	41.1
12	9.3	3.0	1.7	35	46.1	33.3	48.0
13	9.8	3.3	2.0	36	50.6	37.8	56.3
14	10.4	3.6	2.3	37	55.6	42.9	66.2
15	11.0	3.9	2.7	38	61.4	48.9	78.0
16	11.6	4.3	3.1	39	67.9	56.0	92.3
17	12.3	4.8	3.5	40	75.3	64.2	109.4
18	13.1	5.3	4.1	41	83.9	73.9	130.2
19	13.9	5.8	4.7	42	93.7	85.4	155.6
20	14.8	6.4	5.4	43	105.1	99.0	186.5
21	15.8	7.1	6.2	44	118.4	115.3	224.6
22	16.9	7.8	7.1	45	133.9	134.9	271.8

Table 10.6.3.1.2a-2—Coefficients C_{wq} and $C_{w\gamma}$ for Various Groundwater Depths

D_w	C_{wq}	$C_{w\gamma}$
0.0	0.5	0.5
D_f	1.0	0.5
$>1.5B + D_f$	1.0	1.0

Where the position of groundwater is at a depth less than 1.5 times the footing width below the footing base, the bearing resistance is affected. The highest anticipated groundwater level should be used in design.

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MP 9.245, MP 10.189 and MP 10.378
Footing on Bedrock
Factored Bearing Resistance

1) Conservatively assume Nominal or Ultimate Bearing Capacity as 20 ksf
2) Bearing Resistance Factor on Bedroad = 0.45
3) Factored Bearing Resistance at Strength Limit = 0.45 * 20 ksf = 9 ksf, use 9 ksf for Shallow Foundation Design on Bedrock.

Table 8-9

Presumptive values of allowable bearing pressures for spread foundations on rock (modified after NAVFAC, 1986a, AASHTO 2004 with 2006 Interims)

Type of Bearing Material	Consistency In Place	Allowable Bearing Pressure tsf (MPa)	
		Range	Recommended Value for Use
Massive crystalline igneous and metamorphic rock: granite, diorite, basalt, gneiss, thoroughly cemented conglomerate (sound condition allows minor cracks)	Hard, sound rock	120-200 (5.8 - 9.6)	160 (7.7)
Foliated metamorphic rock: Slate, schist (sound condition allows minor cracks)	Medium-hard, sound rock	60-80 (2.9-3.8)	70 (3.4)
Sedimentary rock; hard cemented shales, siltstone, sandstone, limestone without cavities	Medium-hard, sound rock	30-50 (1.4-2.4)	40 (1.9)
Weathered or broken bedrock of any kind except highly argillaceous rock (shale). RQD less than 25	Soft rock	16-24 (0.8-1.2)	20 (1)
Compacted shale or other highly argillaceous rock in sound condition	Soft rock	16-24 (0.8-1.2)	20 (1)

Notes:

1. For preliminary analysis or in the absence of strength tests, design and proportion shallow foundations to distribute their loads by using presumptive values of allowable bearing pressure given in this table. Modify the nominal value of allowable bearing pressure for special conditions described in notes 2 through 8.
2. The maximum bearing pressure beneath the footing produced by eccentric loads that include dead plus normal live load plus permanent lateral loads shall not exceed the above nominal bearing pressure.
3. Bearing pressures up to one-third in excess of the nominal bearing values are permitted for transient live load from wind or earthquake. If overload from wind or earthquake exceeds one-third of nominal bearing pressures, increase allowable bearing pressures by one-third of nominal value.
4. Extend footings on soft rock to a minimum depth of 1.5 in (40 mm) below adjacent ground surface or surface of adjacent floor, whichever elevation is the lowest.
5. For footings on soft rock, increase allowable bearing pressures by 5 percent of the nominal values for each 1 ft (300 mm) of depth below the minimum depth specified in Note 4.
6. Apply the nominal bearing pressures of the three categories of hard or medium hard rock shown above where the base of the foundation lies on rock surface. Where the foundation extends below the rock surface, increase the allowable bearing pressure by 10 percent of the nominal values for each additional 1ft (300 mm) of depth extending below the surface.
7. For footings smaller than 3 ft (1 m) in the least lateral dimension, the allowable bearing pressure shall be the nominal bearing pressure multiplied by the least lateral dimension.
8. If the above-recommended nominal bearing pressure exceeds the unconfined compressive strength of intact specimen, the allowable pressure equals the unconfined compressive strength.

Table 8-10

Suggested values of allowable bearing capacity (Peck, *et al.*, 1974)

RQD (%)	Rock Mass Quality	Allowable Pressure ksf (MPa)
100	Excellent	600 (29)
90	Good	400 (19)
75	Fair	240 (12)
50	Poor	130 (6)
25	Very Poor	60 (3)
0	Soil-like	20 (1)

Use 20 ksf as ultimate Bearing Pressure

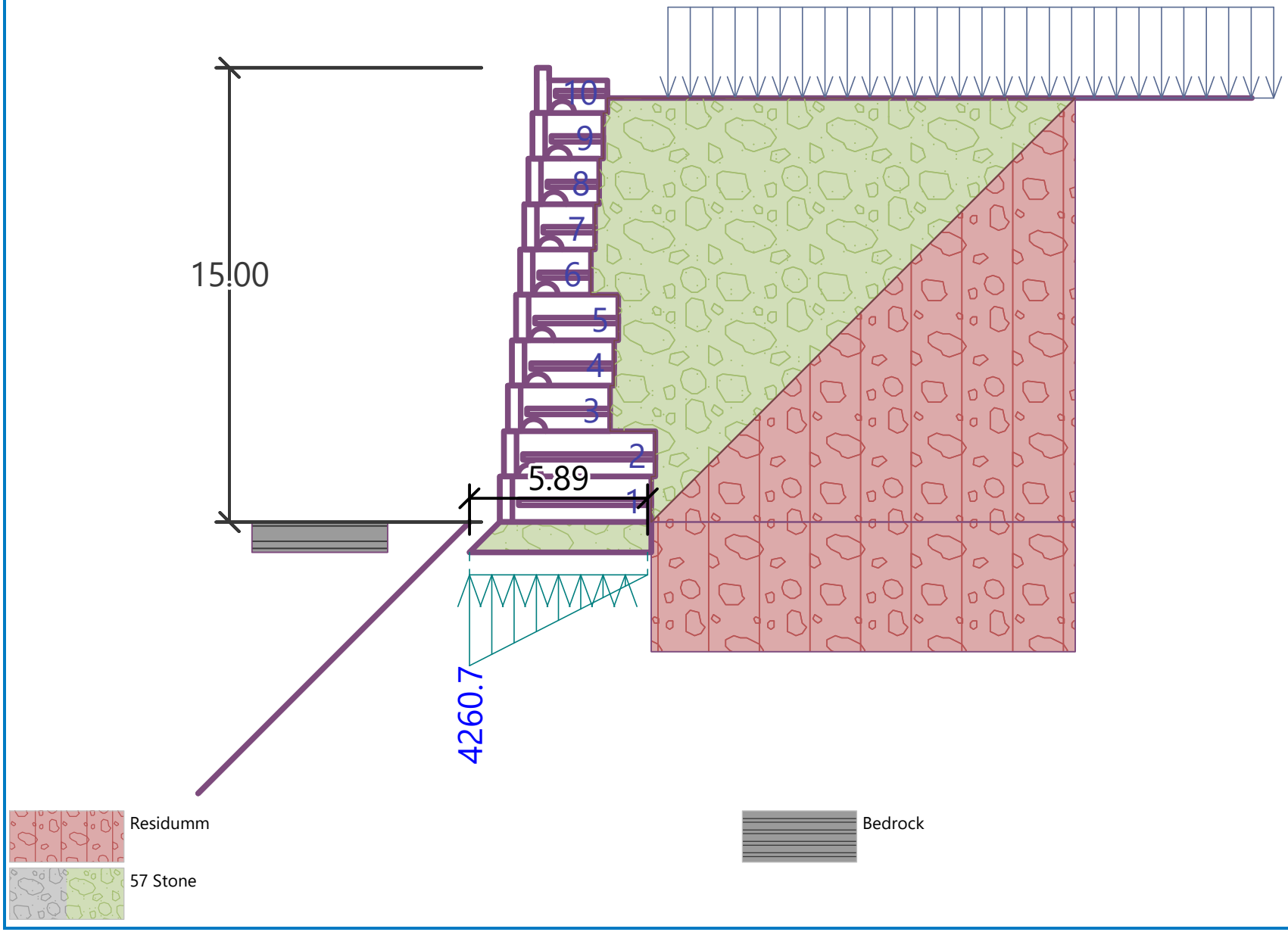
MP 9.245 Wall
(P 365)
Footing on Residuum

VKG

McFarland Rd (FS23)
MP 9.245 (P365)

Name :

Stage - analysis : 1 - -1



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Analysis of Redi Rock wall

Input data

Project : McFarland Rd (FS23)
Part : MP 9.245 (P365)
Customer : EFLHD
Author : VKG
Date : 7/3/2024
Project number : 19-01472-007

Settings

(input for current task)

Wall analysis

Verification methodology : according to LRFD
Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : Mononobe-Okabe
Shape of earth wedge : Calculate as skew
Allowable eccentricity : 0.333
Internal stability : Standard - straight slip surface
Reduction coeff. of contact first block - base : 1.00

Load factors					
Design situation - Strength I					
		Minimum		Maximum	
Dead load of structural components :	DC =	0.90	[–]	1.25	[–]
Dead load of wearing surfaces :	DW =	0.65	[–]	1.50	[–]
Earth pressure - active :	EH_A =	0.90	[–]	1.50	[–]
Earth pressure - at rest :	EH_R =	0.90	[–]	1.35	[–]
Earth surcharge load (permanent) :	ES =	0.75	[–]	1.50	[–]
Vertical pressure of earth fill :	EV =	1.00	[–]	1.35	[–]
Live load surcharge :	LL =	0.00	[–]	1.75	[–]
Water load :	WA =	1.00	[–]	1.00	[–]

Resistance factors			
Design situation - Strength I			
Resistance factor on overturning :	ϕ_o =	0.90	[–]
Resistance factor on sliding :	ϕ_t =	0.90	[–]
Resistance factor on bearing capacity :	ϕ_b =	0.45	[–]
Resistance factor on passive pressure :	ϕ_{VE} =	0.50	[–]

Blocks

No.	Description	Height h [in]	Width w [in]	Unit weight γ [pcf]
1	Block 28	18.00	28.00	120.00
2	Block 41	18.00	40.50	120.00
3	Block 60	18.00	60.00	130.00
4	Top block 24 straight	18.00	24.00	108.00
5	Planter 41	18.00	40.50	120.00

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No.	Description	Height h [in]	Width w [in]	Unit weight γ [pcf]
6	Planter 60	18.00	60.00	112.00
7	Top block 28	18.00	28.00	120.00
8	Top block 41	18.00	40.50	120.00
9	Top block 24 straight garden	18.00	24.00	80.00
10	Block R-5236 HC	36.00	52.00	110.00
11	Block R-7236 HC	36.00	72.00	110.00
12	Block R-9636 HC	36.00	96.00	110.00
13	Block R-41 HC	18.00	40.50	110.00

No.	Description	Min. shear strength F_{min} [lbf/ft]	Max. shear strength F_{max} [lbf/ft]	Friction f [°]
1	Block 28	6061.00	11276.00	44.00
2	Block 41	6061.00	11276.00	44.00
3	Block 60	6061.00	11276.00	44.00
4	Top block 24 straight	6061.00	11276.00	44.00
5	Planter 41	6061.00	11276.00	44.00
6	Planter 60	6061.00	11276.00	44.00
7	Top block 28	6061.00	11276.00	44.00
8	Top block 41	6061.00	11276.00	44.00
9	Top block 24 straight garden	6061.00	11276.00	44.00
10	Block R-5236 HC	4550.00	12000.00	44.00
11	Block R-7236 HC	4550.00	12000.00	44.00
12	Block R-9636 HC	4550.00	12000.00	44.00
13	Block R-41 HC	5358.00	12906.00	37.00

Setbacks

No.	Setback s [in]
1	0.010
2	0.375
3	1.625
4	9.375
5	16.625

Geometry

No. group	Description	Count	Setback s [in]
1	Block 60	2	1.62
2	Block 41	3	1.62
3	Block 28	4	1.62
4	Top block 28	1	-

Base

Geometry

Upper setback a_1 = 0.00 ft

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Lower setback a_2 = 1.00 ft
Height h = 1.00 ft
Width b = 6.00 ft

Material
Soil creating foundation - 57 Stone

Basic soil parameters

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [psf]	γ [pcf]	γ_{su} [pcf]	δ [°]
1	57 Stone		38.00	0.0	110.00	52.50	19.00
2	Bedrock		30.00	1000.0	165.00	107.50	15.00
3	Residumm		34.00	0.0	125.00	62.50	17.00

All soils are considered as cohesionless for at rest pressure analysis.

Soil parameters

57 Stone
Unit weight : γ = 110.0 pcf
Stress-state : effective
Angle of internal friction : φ_{ef} = 38.00 °
Cohesion of soil : c_{ef} = 0.0 psf
Angle of friction struc.-soil : δ = 19.00 °
Saturated unit weight : γ_{sat} = 115.0 pcf

Bedrock
Unit weight : γ = 165.0 pcf
Stress-state : effective
Angle of internal friction : φ_{ef} = 30.00 °
Cohesion of soil : c_{ef} = 1000.0 psf
Angle of friction struc.-soil : δ = 15.00 °
Saturated unit weight : γ_{sat} = 170.0 pcf

Residumm
Unit weight : γ = 125.0 pcf
Stress-state : effective
Angle of internal friction : φ_{ef} = 34.00 °
Cohesion of soil : c_{ef} = 0.0 psf
Angle of friction struc.-soil : δ = 17.00 °
Saturated unit weight : γ_{sat} = 125.0 pcf

Backfill

Assigned soil : 57 Stone
Slope = 45.00 °

Geological profile and assigned soils

Position information
Terrain elevation = 1029.00 ft
Geological profile and assigned soils

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No.	Thickness of layer t [ft]	Depth z [ft]	Elevation [ft]	Assigned soil	Pattern
1	14.00	0.00 .. 14.00	1029.00 .. 1015.00	Residumm	
2	33.50	14.00 .. 47.50	1015.00 .. 981.50	Residumm	
3	-	47.50 .. ∞	981.50 .. -	Residumm	

Terrain profile

Terrain behind the structure is flat.
Depth of terrain below the top of wall h = 1.00 ft.

Water influence

Ground water table is located below the structure.

Input surface surcharges

No.	Surcharge new	Surcharge change	Action	Mag.1 [lbf/ft²]	Mag.2 [lbf/ft²]	Ord.x x [ft]	Length l [ft]	Depth z [ft]
1	Yes		permanent	250.00		2.00	20.00	on terrain

No.	Name
1	Traffic

Resistance on front face of the structure

Resistance on front face of the structure: not considered
Soil on front face of the structure - Bedrock
Soil thickness in front of structure $h = 1.00$ ft
Soil slope in front of structure $\beta = -45.00$ °

Settings of the stage of construction

Design situation : Strength I
Reduction of soil/soil friction angle : do not reduce

Verification No. 1

Active pressure distribution behind the structure (without surcharge)

Layer No.	Start [ft] End [ft]	σ_z [psf]	σ_w [psf]	Pressure [psf]	Hor. comp. [psf]	Vert. comp. [psf]
1	0.00	0.0	0.0	0.0	0.0	0.0
	0.50	55.0	0.0	11.9	11.3	3.9
2	0.50	55.0	0.0	10.1	9.9	2.4
	4.93	542.5	0.0	100.1	97.2	23.9
3	4.93	542.5	0.0	294.4	129.1	264.6
	6.50	715.0	0.0	388.0	170.1	348.7
4	6.50	715.0	0.0	139.4	134.3	37.4
	8.28	911.0	0.0	177.6	171.1	47.6
5	8.28	911.0	0.0	494.3	216.7	444.3
	11.00	1210.0	0.0	656.6	287.8	590.2
6	11.00	1210.0	0.0	242.4	232.6	68.5
	14.00	1540.0	0.0	308.6	296.0	87.2
7	14.00	1540.0	0.0	394.9	377.7	115.5
	15.00	1665.0	0.0	427.0	408.3	124.8

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Forces acting on construction

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0.0	-6.35	6440.6	3.23	0.900	0.900	1.250
Weight - earth wedge	0.0	-4.91	222.7	5.20	1.000	1.000	1.350
Weight - earth wedge	0.0	-9.02	78.1	4.36	1.000	1.000	1.350
Active pressure	2618.1	-4.89	2375.7	5.34	1.500	1.500	1.500
Traffic	591.5	-6.69	345.6	5.17	1.500	1.500	1.500

Verification of complete wall

Check for overturning stability

Resisting moment M_{res} = 37741.4 lbfft/ft
Overturning moment M_{ovr} = 25140.0 lbfft/ft

Capacity demand ratio CDR = 1.50
Wall for overturning is SATISFACTORY

Check for slip

Resisting horizontal force H_{res} = 6179.54 lbf/ft
Active horizontal force H_{act} = 4814.30 lbf/ft

Capacity demand ratio CDR = 1.28
Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Dimensioning No. 1

Active pressure distribution behind the structure (without surcharge)

Layer No.	Start [ft] End [ft]	σ_Z [psf]	σ_W [psf]	Pressure [psf]	Hor. comp. [psf]	Vert. comp. [psf]
1	0.00	0.0	0.0	0.0	0.0	0.0
	0.50	55.0	0.0	11.9	11.3	3.9
2	0.50	55.0	0.0	10.1	9.9	2.4
	4.93	542.5	0.0	100.1	97.2	23.9
3	4.93	542.5	0.0	294.4	129.1	264.6
	6.50	715.0	0.0	388.0	170.1	348.7
4	6.50	715.0	0.0	139.4	134.3	37.4
	8.28	911.0	0.0	177.6	171.1	47.6
5	8.28	911.0	0.0	494.3	216.7	444.3
	11.00	1210.0	0.0	656.6	287.8	590.2
6	11.00	1210.0	0.0	242.4	232.6	68.5
	14.00	1539.8	0.0	308.5	295.9	87.2
7	14.00	1539.8	0.0	368.2	356.6	91.7
	14.00	1540.0	0.0	368.3	356.7	91.7

Forces acting on construction

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0.0	-6.02	5780.6	2.26	0.900	0.900	1.250
Weight - earth wedge	0.0	-3.91	222.7	4.20	1.000	1.000	1.350

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Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - earth wedge	0.0	-8.02	78.1	3.36	1.000	1.000	1.350
Active pressure	2225.2	-4.67	2255.6	4.31	1.500	1.500	1.500
Traffic	531.7	-6.39	327.4	4.12	1.500	1.500	1.500

Verification of block No. 1

Check for overturning stability

Resisting moment M_{res} = 26576.2 lbfft/ft
Overturning moment M_{ovr} = 20669.1 lbfft/ft

Capacity demand ratio CDR = 1.29
Joint for overturning stability is SATISFACTORY

Check for slip

Resisting horizontal force H_{res} = 6594.11 lbf/ft
Active horizontal force H_{act} = 4135.28 lbf/ft

Capacity demand ratio CDR = 1.59
Joint for verification is SATISFACTORY

Bearing capacity of foundation soil

Design load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]	Eccentricity [–]	Stress [psf]
1	13016.2	12539.03	4814.30	0.173	3195.6
2	13743.7	10179.50	4814.30	0.225	3084.9

Service load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]
1	8370.7	9462.88	3209.53

Verification of foundation soil

Stress in the footing bottom : trapezoid

Eccentricity verification

Max. eccentricity of normal force e = 0.225
Maximum allowable eccentricity e_{alw} = 0.333

Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity

Ultimate bearing capacity of found. soil R = 1500.0 psf
Partial factor on bearing capacity γ_{Rv} = 0.45
Max. stress at footing bottom σ = 4260.7 psf
Allowable bearing capacity of foundation soil R_d = 675.0 psf
Capacity demand ratio CDR = 0.2

Bearing capacity of foundation soil is NOT SATISFACTORY

Overall verification - bearing capacity of found. soil is NOT SATISFACTORY

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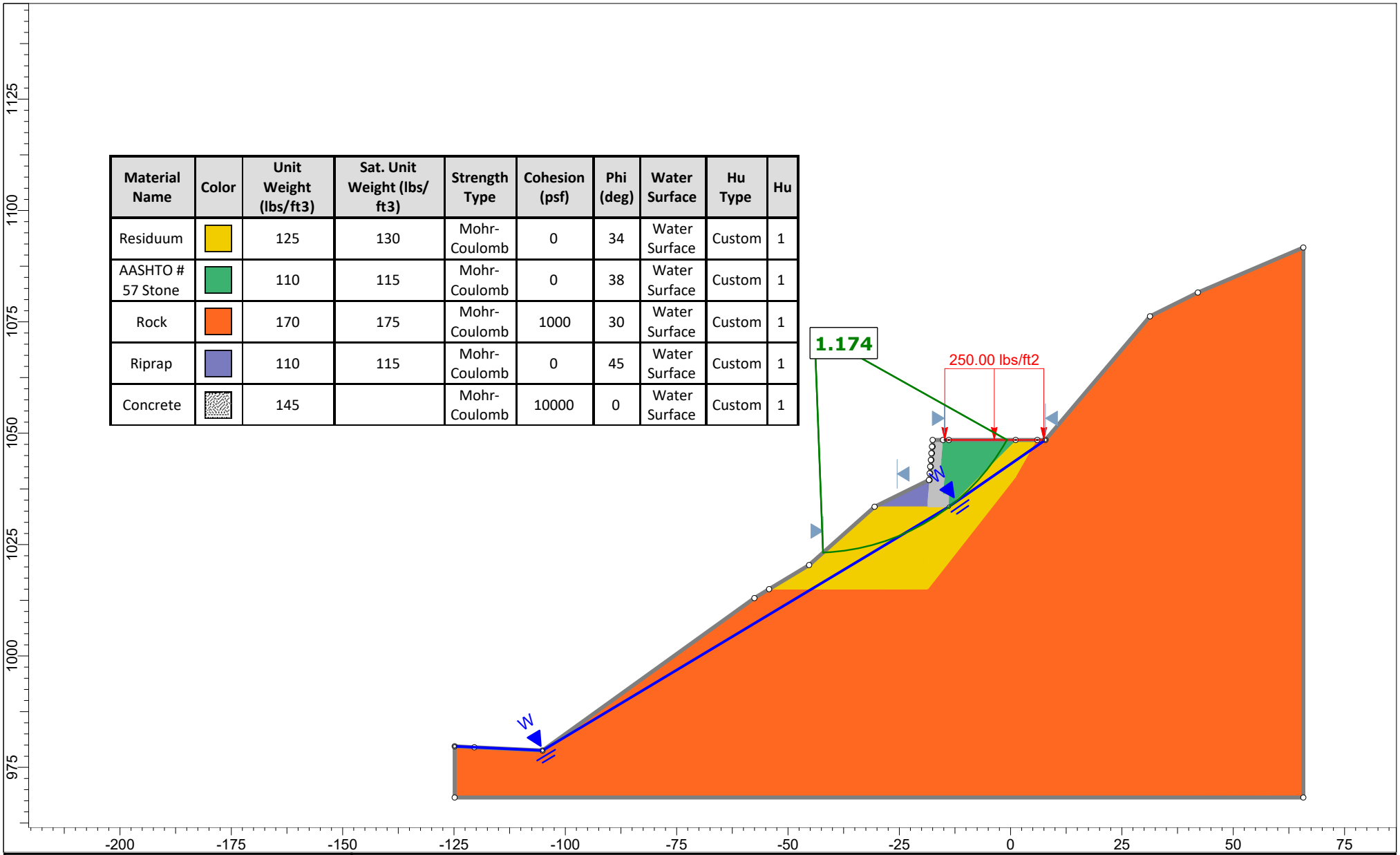
Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Residuum		125	130	Mohr-Coulomb	0	34	Water Surface	Custom	1
AASHTO # 57 Stone		110	115	Mohr-Coulomb	0	38	Water Surface	Custom	1
Rock		170	175	Mohr-Coulomb	1000	30	Water Surface	Custom	1
Riprap		110	115	Mohr-Coulomb	0	45	Water Surface	Custom	1
Concrete		145		Mohr-Coulomb	10000	0	Water Surface	Custom	1

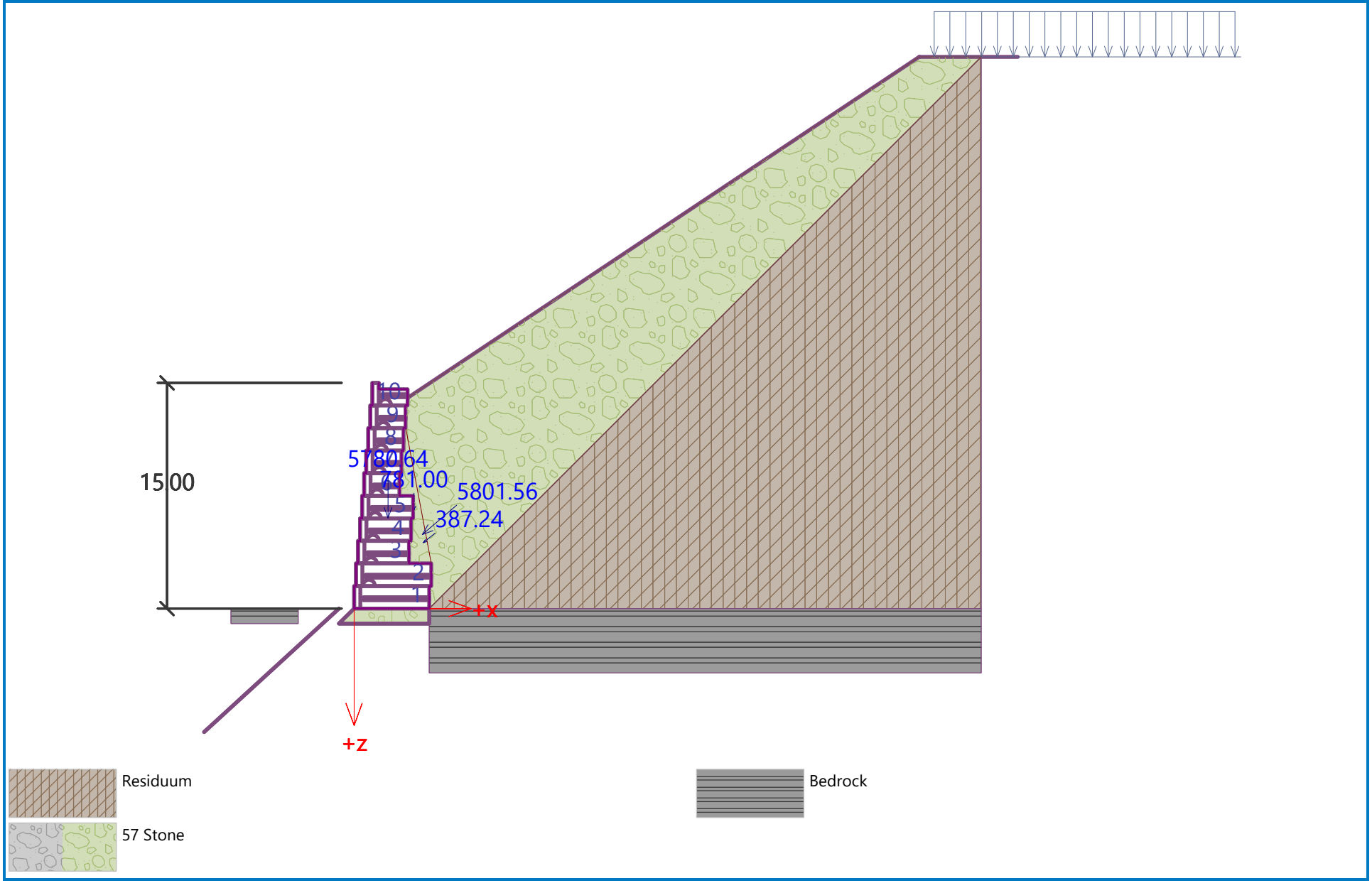


Project	Wall 365 Station 2+30		
Group	Wall close to roadway and foundation in residuum	Scenario	Without seismic load
Drawn By	SY	Company	JMT
Date	07/07/2023, 11:03:46 AM	File Name	P365 Riprip Slope - Wall - updated design 07032024.slmd

SLIDEINTERPRET 9.022

MP 9.245 Wall
(P 365)
Footing on Weathered Rock

Name : | **Stage - analysis : 1 - 1**



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Analysis of Redi Rock wall

Input data

Project : McFarland Rd (FS23)
Part : MP9.245 (P365)
Customer : EFLHD
Author : VKG
Date : 5/6/2024
Project number : 19-01472-007

Settings

(input for current task)

Wall analysis

Verification methodology : according to LRFD
Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : Mononobe-Okabe
Shape of earth wedge : Calculate as skew
Allowable eccentricity : 0.333
Internal stability : Standard - straight slip surface
Reduction coeff. of contact first block - base : 1.00

Load factors					
Design situation - Strength I					
		Minimum		Maximum	
Dead load of structural components :	DC =	0.90	[–]	1.25	[–]
Dead load of wearing surfaces :	DW =	0.65	[–]	1.50	[–]
Earth pressure - active :	EH_A =	0.90	[–]	1.50	[–]
Earth pressure - at rest :	EH_R =	0.90	[–]	1.35	[–]
Earth surcharge load (permanent) :	ES =	0.75	[–]	1.50	[–]
Vertical pressure of earth fill :	EV =	1.00	[–]	1.35	[–]
Live load surcharge :	LL =	0.00	[–]	1.75	[–]
Water load :	WA =	1.00	[–]	1.00	[–]

Resistance factors			
Design situation - Strength I			
Resistance factor on overturning :	ϕ_o =	0.90	[–]
Resistance factor on sliding :	ϕ_t =	0.90	[–]
Resistance factor on bearing capacity :	ϕ_b =	0.45	[–]
Resistance factor on passive pressure :	ϕ_{VE} =	0.50	[–]

Blocks

No.	Description	Height h [in]	Width w [in]	Unit weight γ [pcf]
1	Block 28	18.00	28.00	120.00
2	Block 41	18.00	40.50	120.00
3	Block 60	18.00	60.00	130.00
4	Top block 24 straight	18.00	24.00	108.00
5	Planter 41	18.00	40.50	120.00

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No.	Description	Height h [in]	Width w [in]	Unit weight γ [pcf]
6	Planter 60	18.00	60.00	112.00
7	Top block 28	18.00	28.00	120.00
8	Top block 41	18.00	40.50	120.00
9	Top block 24 straight garden	18.00	24.00	80.00
10	Block R-5236 HC	36.00	52.00	110.00
11	Block R-7236 HC	36.00	72.00	110.00
12	Block R-9636 HC	36.00	96.00	110.00
13	Block R-41 HC	18.00	40.50	110.00

No.	Description	Min. shear strength F_{min} [lbf/ft]	Max. shear strength F_{max} [lbf/ft]	Friction f [°]
1	Block 28	6061.00	11276.00	44.00
2	Block 41	6061.00	11276.00	44.00
3	Block 60	6061.00	11276.00	44.00
4	Top block 24 straight	6061.00	11276.00	44.00
5	Planter 41	6061.00	11276.00	44.00
6	Planter 60	6061.00	11276.00	44.00
7	Top block 28	6061.00	11276.00	44.00
8	Top block 41	6061.00	11276.00	44.00
9	Top block 24 straight garden	6061.00	11276.00	44.00
10	Block R-5236 HC	4550.00	12000.00	44.00
11	Block R-7236 HC	4550.00	12000.00	44.00
12	Block R-9636 HC	4550.00	12000.00	44.00
13	Block R-41 HC	5358.00	12906.00	37.00

Setbacks

No.	Setback s [in]
1	0.010
2	0.375
3	1.625
4	9.375
5	16.625

Geometry

No. group	Description	Count	Setback s [in]
1	Block 60	2	1.62
2	Block 41	3	1.62
3	Block 28	4	1.62
4	Top block 28	1	-

Base

Geometry

Upper setback a_1 = 0.00 ft

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Lower setback a_2 = 1.00 ft
Height h = 1.00 ft
Width b = 6.00 ft

Material
Soil creating foundation - 57 Stone

Basic soil parameters

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [psf]	γ [pcf]	γ_{su} [pcf]	δ [°]
1	57 Stone		38.00	0.0	110.00	52.50	19.00
2	Residuum		34.00	0.0	125.00	62.50	17.00
3	Bedrock		30.00	1000.0	165.00	107.50	15.00

All soils are considered as cohesionless for at rest pressure analysis.

Soil parameters

57 Stone
Unit weight : γ = 110.0 pcf
Stress-state : effective
Angle of internal friction : φ_{ef} = 38.00 °
Cohesion of soil : c_{ef} = 0.0 psf
Angle of friction struc.-soil : δ = 19.00 °
Saturated unit weight : γ_{sat} = 115.0 pcf

Residuum
Unit weight : γ = 125.0 pcf
Stress-state : effective
Angle of internal friction : φ_{ef} = 34.00 °
Cohesion of soil : c_{ef} = 0.0 psf
Angle of friction struc.-soil : δ = 17.00 °
Saturated unit weight : γ_{sat} = 125.0 pcf

Bedrock
Unit weight : γ = 165.0 pcf
Stress-state : effective
Angle of internal friction : φ_{ef} = 30.00 °
Cohesion of soil : c_{ef} = 1000.0 psf
Angle of friction struc.-soil : δ = 15.00 °
Saturated unit weight : γ_{sat} = 170.0 pcf

Backfill

Assigned soil : 57 Stone
Slope = 45.00 °

Geological profile and assigned soils

Position information
Terrain elevation = 1029.00 ft
Geological profile and assigned soils

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No.	Thickness of layer t [ft]	Depth z [ft]	Elevation [ft]	Assigned soil	Pattern
1	14.00	0.00 .. 14.00	1029.00 .. 1015.00	Residuum	
2	33.50	14.00 .. 47.50	1015.00 .. 981.50	Bedrock	
3	-	47.50 .. ∞	981.50 .. -	Bedrock	

Terrain profile

Terrain behind construction has the slope 1: 1.50 (slope angle is 33.70 °).
Depth of terrain below the top of wall h = 1.00 ft.
Embankment height is 22.68 ft, embankment length is 34.00 ft.

Water influence

Ground water table is located below the structure.

Input surface surcharges

No.	Surcharge new	Surcharge change	Action	Mag.1 [lbf/ft²]	Mag.2 [lbf/ft²]	Ord.x x [ft]	Length l [ft]	Depth z [ft]
1	Yes		permanent	250.00		35.00	20.00	on terrain

No.	Name
1	Traffic

Resistance on front face of the structure

Resistance on front face of the structure: not considered
Soil on front face of the structure - Bedrock
Soil thickness in front of structure h = 1.00 ft
Soil slope in front of structure β = -42.50 °

Settings of the stage of construction

Design situation : Strength I
Reduction of soil/soil friction angle : do not reduce

Verification No. 1

Active pressure distribution behind the structure (without surcharge)

Layer No.	Start [ft] End [ft]	σ_z [psf]	σ_w [psf]	Pressure [psf]	Hor. comp. [psf]	Vert. comp. [psf]
1	0.00	0.0	0.0	0.0	0.0	0.0
	0.50	55.0	0.0	22.0	20.8	7.1
2	0.50	55.0	0.0	18.3	17.8	4.4
	1.93	212.0	0.0	70.6	68.5	16.9
3	1.93	212.0	0.0	144.9	95.7	108.9
	6.50	715.0	0.0	488.9	322.7	367.2
4	6.50	715.0	0.0	488.9	322.7	367.2
	11.00	1210.0	0.0	827.3	546.2	621.4
5	11.00	1210.0	0.0	441.5	423.5	124.8
	14.00	1540.0	0.0	561.9	539.0	158.8
6	14.00	1540.0	0.0	0.0	0.0	0.0
	15.00	1705.0	0.0	0.0	0.0	0.0

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Forces acting on construction

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0.0	-6.35	6440.6	3.23	0.900	0.900	1.250
Weight - earth wedge	0.0	-7.53	781.0	4.99	1.000	1.000	1.350
Active pressure	4422.2	-5.93	3755.0	5.54	1.500	1.500	1.500
Traffic	300.9	-5.38	257.7	5.63	1.500	1.500	1.500

Verification of complete wall

Check for overturning stability

Resisting moment M_{res} = 50406.7 lbfft/ft
Overturning moment M_{ovr} = 41734.1 lbfft/ft

Capacity demand ratio CDR = 1.21
Wall for overturning is SATISFACTORY

Check for slip

Resisting horizontal force H_{res} = 8585.04 lbf/ft
Active horizontal force H_{act} = 7084.63 lbf/ft

Capacity demand ratio CDR = 1.21
Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Dimensioning No. 1

Active pressure distribution behind the structure (without surcharge)

Layer No.	Start [ft] End [ft]	σ_Z [psf]	σ_W [psf]	Pressure [psf]	Hor. comp. [psf]	Vert. comp. [psf]
1	0.00	0.0	0.0	0.0	0.0	0.0
	0.50	55.0	0.0	22.0	20.8	7.1
2	0.50	55.0	0.0	18.3	17.8	4.4
	1.93	212.0	0.0	70.6	68.5	16.9
3	1.93	212.0	0.0	144.9	95.7	108.9
	6.50	715.0	0.0	488.9	322.7	367.2
4	6.50	715.0	0.0	488.9	322.7	367.2
	11.00	1210.0	0.0	827.3	546.2	621.4
5	11.00	1210.0	0.0	441.5	423.5	124.8
	14.00	1539.8	0.0	561.8	538.9	158.8
6	14.00	1539.8	0.0	663.1	642.2	165.1
	14.00	1540.0	0.0	663.2	642.3	165.1

Forces acting on construction

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0.0	-6.02	5780.6	2.26	0.900	0.900	1.250
Weight - earth wedge	0.0	-6.53	781.0	3.99	1.000	1.000	1.350
Active pressure	4422.4	-4.93	3755.1	4.54	1.500	1.500	1.500
Traffic	300.9	-4.38	243.7	4.61	1.500	1.500	1.500

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Verification of block No. 1

Check for overturning stability

Resisting moment M_{res} = 37906.1 lbfft/ft
Overturning moment M_{ovr} = 34649.4 lbfft/ft

Capacity demand ratio CDR = 1.09
Joint for overturning stability is SATISFACTORY

Check for slip

Resisting horizontal force H_{res} = 8425.06 lbf/ft
Active horizontal force H_{act} = 7084.96 lbf/ft

Capacity demand ratio CDR = 1.19
Joint for verification is SATISFACTORY

Bearing capacity of foundation soil

Design load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]	Eccentricity [–]	Stress [psf]
1	22454.7	15124.31	7084.63	0.247	4990.4
2	23516.8	12596.74	7084.63	0.311	5558.5

Service load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]
1	14567.4	11234.41	4723.08

Verification of foundation soil

Stress in the footing bottom : trapezoid

Eccentricity verification

Max. eccentricity of normal force e = 0.311
Maximum allowable eccentricity e_{alw} = 0.333

Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity

Ultimate bearing capacity of found. soil R = 20000.0 psf
Partial factor on bearing capacity γ_{Rv} = 0.45
Max. stress at footing bottom σ = 7411.4 psf
Allowable bearing capacity of foundation soil R_d = 9000.0 psf
Capacity demand ratio CDR = 1.2

Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

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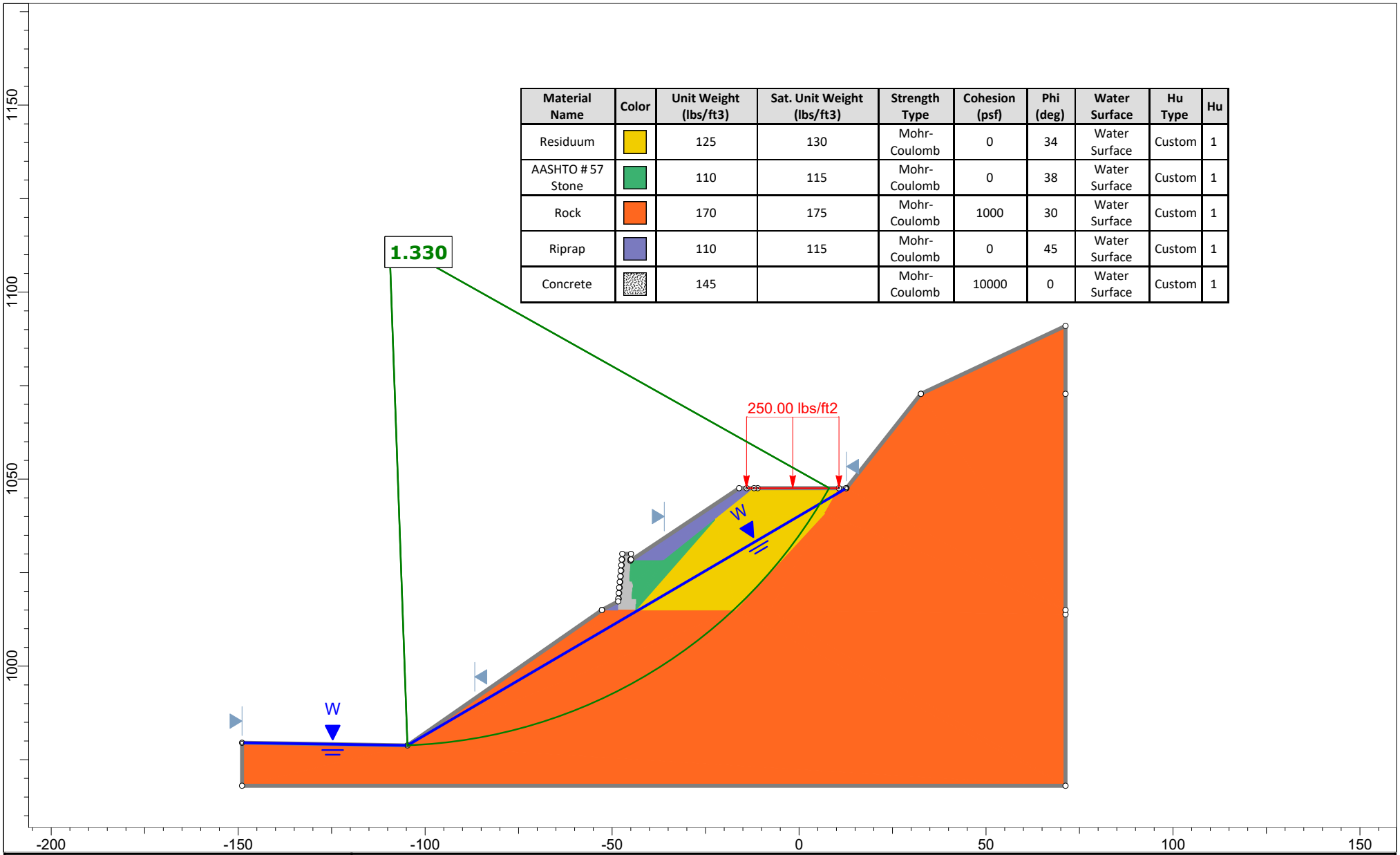
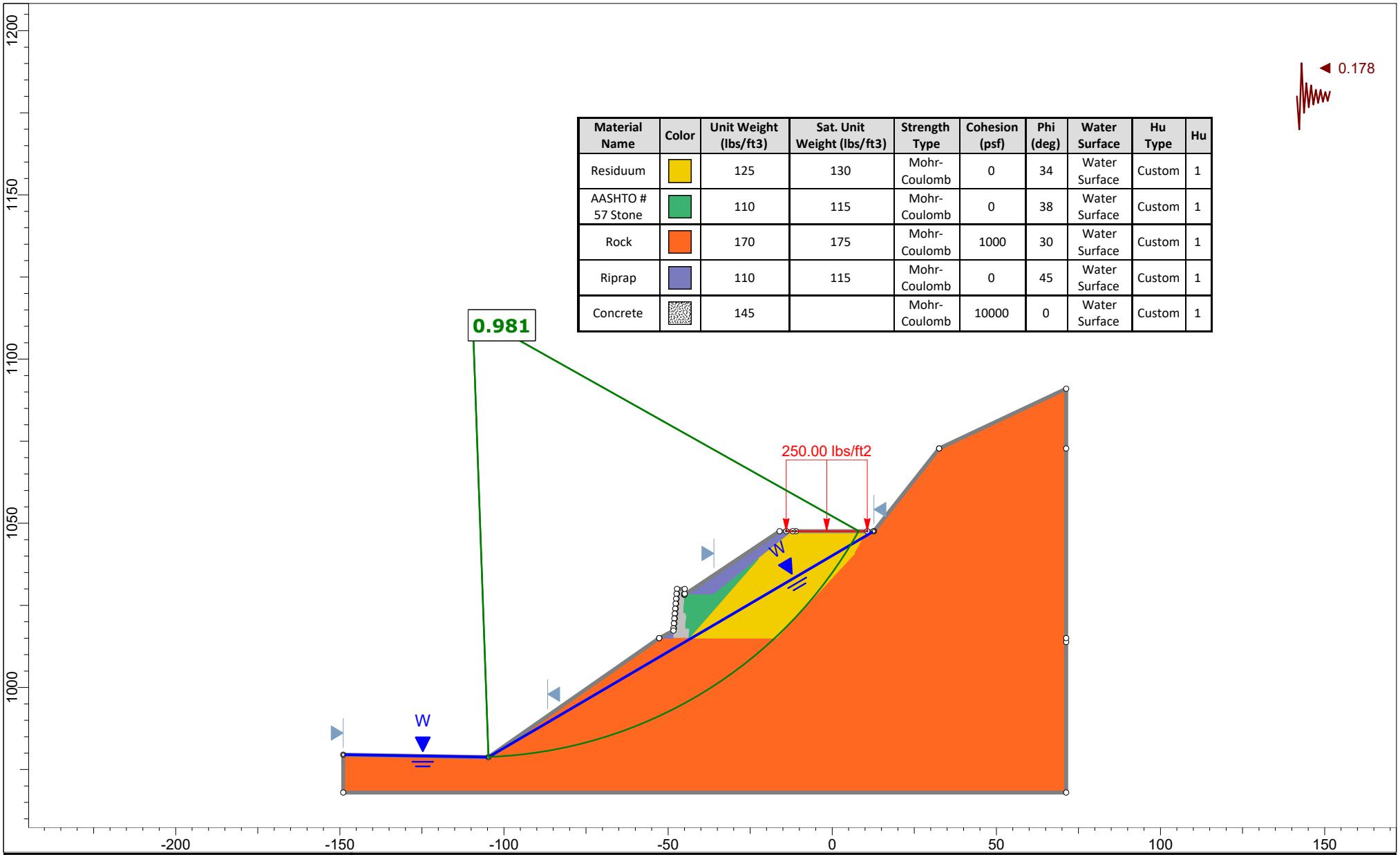
Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Residuum		125	130	Mohr-Coulomb	0	34	Water Surface	Custom	1
AASHTO # 57 Stone		110	115	Mohr-Coulomb	0	38	Water Surface	Custom	1
Rock		170	175	Mohr-Coulomb	1000	30	Water Surface	Custom	1
Riprap		110	115	Mohr-Coulomb	0	45	Water Surface	Custom	1
Concrete		145		Mohr-Coulomb	10000	0	Water Surface	Custom	1



Project	Wall 365 Station 2+30		
Group	Wall Foundation on Bedrock	Scenario	Without seismic load
Drawn By	SY	Company	JMT
Date	07/05/2024, 15:21:33 PM	File Name	P365 Riprip Slope - Wall - original design 07032024.slmd

SLIDEINTERPRET 9.022

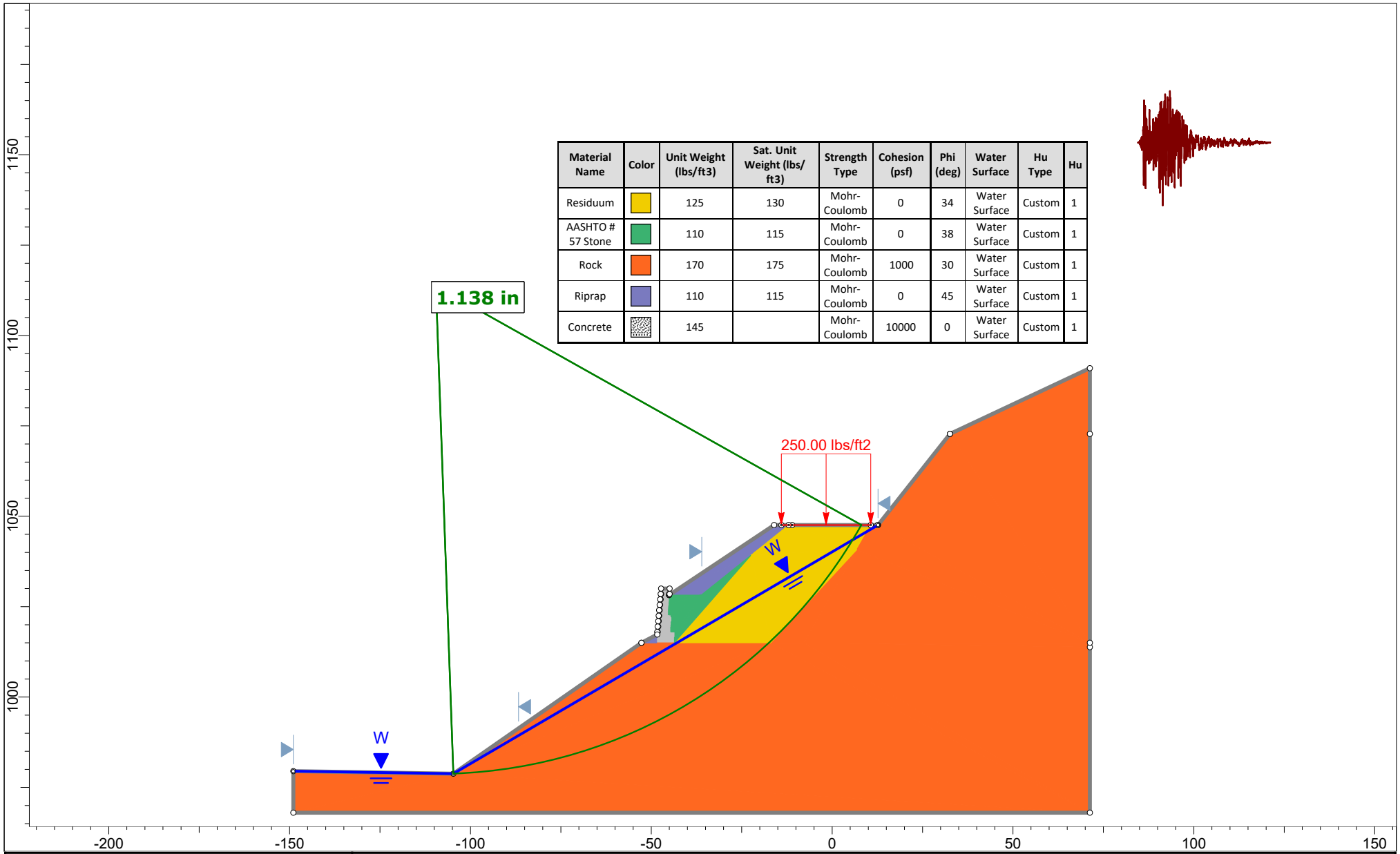
Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Residuum		125	130	Mohr-Coulomb	0	34	Water Surface	Custom	1
AASHTO # 57 Stone		110	115	Mohr-Coulomb	0	38	Water Surface	Custom	1
Rock		170	175	Mohr-Coulomb	1000	30	Water Surface	Custom	1
Riprap		110	115	Mohr-Coulomb	0	45	Water Surface	Custom	1
Concrete		145		Mohr-Coulomb	10000	0	Water Surface	Custom	1



Project	Wall 365 Station 2+30		
Group	Wall Foundation on Bedrock	Scenario	With seismic load
Drawn By	SY	Company	JMT
Date	07/05/2024, 15:11:25 PM	File Name	P365 Riprip Slope - Wall - original design 07032024.slmd

SLIDEINTERPRET 9.022

Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Residuum		125	130	Mohr-Coulomb	0	34	Water Surface	Custom	1
AASHTO # 57 Stone		110	115	Mohr-Coulomb	0	38	Water Surface	Custom	1
Rock		170	175	Mohr-Coulomb	1000	30	Water Surface	Custom	1
Riprap		110	115	Mohr-Coulomb	0	45	Water Surface	Custom	1
Concrete		145		Mohr-Coulomb	10000	0	Water Surface	Custom	1

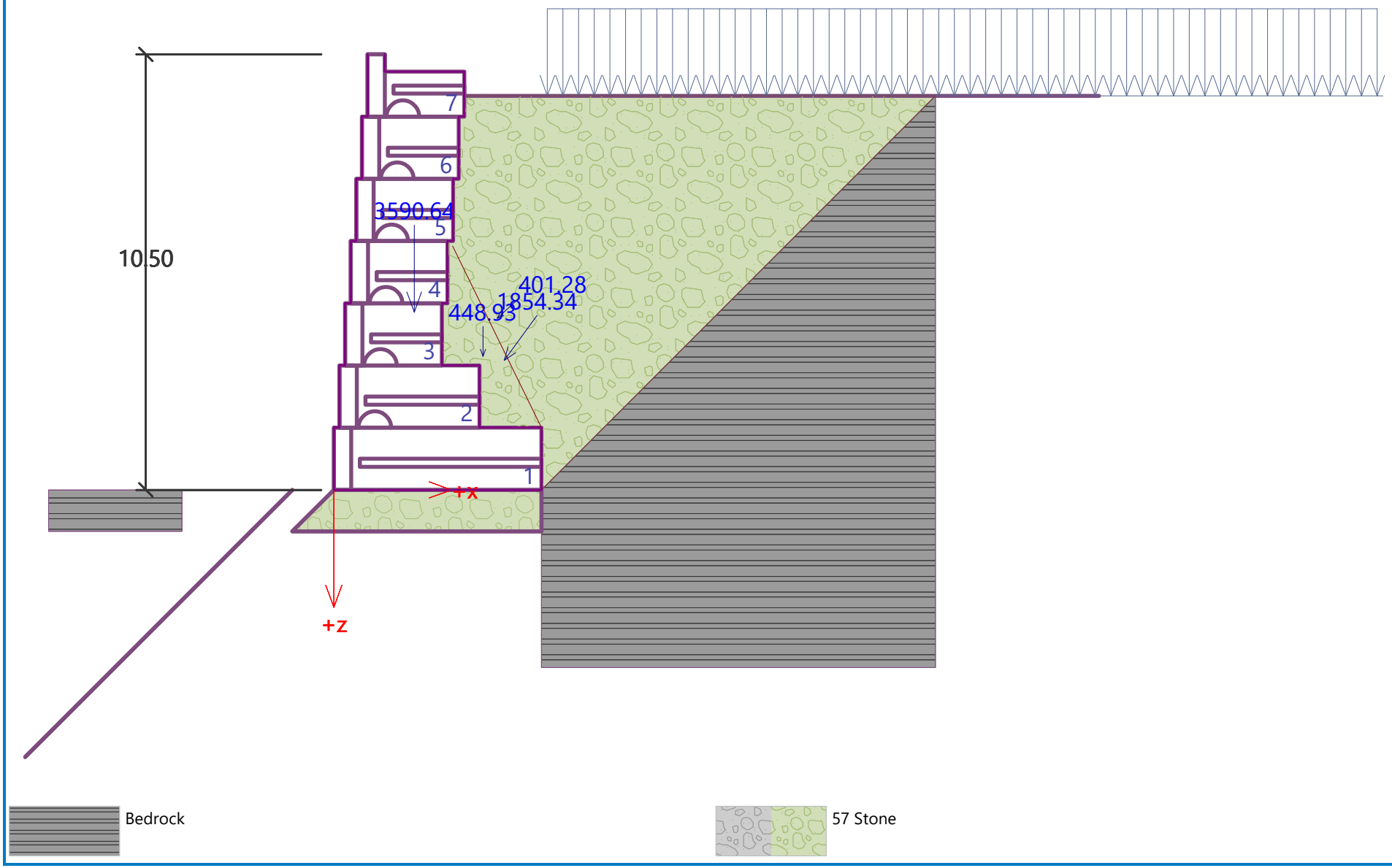


Project	Wall 365 Station 2+30		
Group	Wall Foundation on Bedrock	Scenario	Newmark Displacement
Drawn By	SY	Company	JMT
Date	07/07/2023, 09:16:25 AM	File Name	P365 Riprip Slope - Wall - original design 07032024.slmd

SLIDEINTERPRET 9.022

MP 10.189 Wall
(P 370)

Name : | **Stage - analysis : 1 - 1**



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Analysis of Redi Rock wall

Input data

Project : McFarland Rd (FS23)
Part : MP10.189 (P370)
Customer : EFLHD
Author : VKG
Date : 5/6/2024
Project number : 19-01472-007

Settings

(input for current task)

Wall analysis

Verification methodology : according to LRFD
Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : Mononobe-Okabe
Shape of earth wedge : Calculate as skew
Allowable eccentricity : 0.333
Internal stability : Standard - straight slip surface
Reduction coeff. of contact first block - base : 1.00

Load factors					
Design situation - Strength I					
		Minimum		Maximum	
Dead load of structural components :	DC =	0.90	[–]	1.25	[–]
Dead load of wearing surfaces :	DW =	0.65	[–]	1.50	[–]
Earth pressure - active :	EH_A =	0.90	[–]	1.50	[–]
Earth pressure - at rest :	EH_R =	0.90	[–]	1.35	[–]
Earth surcharge load (permanent) :	ES =	0.75	[–]	1.50	[–]
Vertical pressure of earth fill :	EV =	1.00	[–]	1.35	[–]
Live load surcharge :	LL =	0.00	[–]	1.75	[–]
Water load :	WA =	1.00	[–]	1.00	[–]

Resistance factors			
Design situation - Strength I			
Resistance factor on overturning :	ϕ_o =	0.90	[–]
Resistance factor on sliding :	ϕ_t =	0.90	[–]
Resistance factor on bearing capacity :	ϕ_b =	0.45	[–]
Resistance factor on passive pressure :	ϕ_{VE} =	0.50	[–]

Blocks

No.	Description	Height h [in]	Width w [in]	Unit weight γ [pcf]
1	Block 28	18.00	28.00	120.00
2	Block 41	18.00	40.50	120.00
3	Block 60	18.00	60.00	130.00
4	Top block 24 straight	18.00	24.00	108.00
5	Planter 41	18.00	40.50	120.00

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No.	Description	Height h [in]	Width w [in]	Unit weight γ [pcf]
6	Planter 60	18.00	60.00	112.00
7	Top block 28	18.00	28.00	120.00
8	Top block 41	18.00	40.50	120.00
9	Top block 24 straight garden	18.00	24.00	80.00
10	Block R-5236 HC	36.00	52.00	110.00
11	Block R-7236 HC	36.00	72.00	110.00
12	Block R-9636 HC	36.00	96.00	110.00
13	Block R-41 HC	18.00	40.50	110.00

No.	Description	Min. shear strength F_{min} [lbf/ft]	Max. shear strength F_{max} [lbf/ft]	Friction f [°]
1	Block 28	6061.00	11276.00	44.00
2	Block 41	6061.00	11276.00	44.00
3	Block 60	6061.00	11276.00	44.00
4	Top block 24 straight	6061.00	11276.00	44.00
5	Planter 41	6061.00	11276.00	44.00
6	Planter 60	6061.00	11276.00	44.00
7	Top block 28	6061.00	11276.00	44.00
8	Top block 41	6061.00	11276.00	44.00
9	Top block 24 straight garden	6061.00	11276.00	44.00
10	Block R-5236 HC	4550.00	12000.00	44.00
11	Block R-7236 HC	4550.00	12000.00	44.00
12	Block R-9636 HC	4550.00	12000.00	44.00
13	Block R-41 HC	5358.00	12906.00	37.00

Setbacks

No.	Setback s [in]
1	0.010
2	0.375
3	1.625
4	9.375
5	16.625

Geometry

No. group	Description	Count	Setback s [in]
1	Block 60	1	1.62
2	Block 41	1	1.62
3	Block 28	4	1.62
4	Top block 28	1	-

Base

Geometry

Upper setback a_1 = 0.00 ft

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Lower setback a_2 = 1.00 ft
Height h = 1.00 ft
Width b = 6.00 ft

Material
Soil creating foundation - 57 Stone

Basic soil parameters

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [psf]	γ [pcf]	γ_{su} [pcf]	δ [°]
1	57 Stone		38.00	0.0	110.00	52.50	19.00
2	Bedrock		30.00	1000.0	165.00	107.50	15.00

All soils are considered as cohesionless for at rest pressure analysis.

Soil parameters

57 Stone
Unit weight : γ = 110.0 pcf
Stress-state : effective
Angle of internal friction : φ_{ef} = 38.00 °
Cohesion of soil : c_{ef} = 0.0 psf
Angle of friction struc.-soil : δ = 19.00 °
Saturated unit weight : γ_{sat} = 115.0 pcf

Bedrock
Unit weight : γ = 165.0 pcf
Stress-state : effective
Angle of internal friction : φ_{ef} = 30.00 °
Cohesion of soil : c_{ef} = 1000.0 psf
Angle of friction struc.-soil : δ = 15.00 °
Saturated unit weight : γ_{sat} = 170.0 pcf

Backfill

Assigned soil : 57 Stone
Slope = 45.00 °

Geological profile and assigned soils

Position information
Terrain elevation = 1029.00 ft

Geological profile and assigned soils

No.	Thickness of layer t [ft]	Depth z [ft]	Elevation [ft]	Assigned soil	Pattern
1	14.00	0.00 .. 14.00	1029.00 .. 1015.00	Bedrock	
2	33.50	14.00 .. 47.50	1015.00 .. 981.50	Bedrock	
3	-	47.50 .. ∞	981.50 .. -	Bedrock	

Terrain profile

Terrain behind the structure is flat.

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Depth of terrain below the top of wall h = 1.00 ft.

Water influence

Ground water table is located below the structure.

Input surface surcharges

No.	Surcharge new	Surcharge change	Action	Mag.1 [lbf/ft²]	Mag.2 [lbf/ft²]	Ord.x x [ft]	Length l [ft]	Depth z [ft]
1	Yes		permanent	250.00		2.00	20.00	on terrain

No.	Name
1	Traffic

Resistance on front face of the structure

Resistance on front face of the structure: not considered
Soil on front face of the structure - Bedrock
Soil thickness in front of structure h = 1.00 ft
Soil slope in front of structure β = -45.00 °

Settings of the stage of construction

Design situation : Strength I
Reduction of soil/soil friction angle : do not reduce

Verification No. 1

Active pressure distribution behind the structure (without surcharge)

Layer No.	Start [ft] End [ft]	σ_Z [psf]	σ_W [psf]	Pressure [psf]	Hor. comp. [psf]	Vert. comp. [psf]
1	0.00	0.0	0.0	0.0	0.0	0.0
	0.50	55.0	0.0	11.9	11.3	3.9
2	0.50	55.0	0.0	10.1	9.9	2.4
	3.62	398.3	0.0	73.5	71.3	17.6
3	3.62	398.3	0.0	216.1	94.7	194.3
	6.50	715.0	0.0	388.0	170.1	348.7
4	6.50	715.0	0.0	388.0	170.1	348.7
	8.00	880.0	0.0	477.5	209.3	429.2
5	8.00	880.0	0.0	191.1	180.7	62.2
	9.50	1045.0	0.0	226.9	214.6	73.9
6	9.50	1045.0	0.0	0.0	0.0	0.0
	10.50	1210.0	0.0	0.0	0.0	0.0

Forces acting on construction

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0.0	-4.54	4250.6	2.95	0.900	0.900	1.250
Weight - earth wedge	0.0	-4.22	448.9	4.60	1.000	1.000	1.350
Active pressure	1091.7	-4.12	1499.4	5.11	1.500	1.500	1.500
Traffic	294.8	-5.13	291.3	5.01	1.500	1.500	1.500

Verification of complete wall

Check for overturning stability

Resisting moment M_{res} = 24303.0 lbfft/ft
Overturning moment M_{ovr} = 9019.6 lbfft/ft

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Capacity demand ratio CDR = 2.69
Wall for overturning is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 8267.43 lbf/ft
Active horizontal force H_{act} = 2079.79 lbf/ft

Capacity demand ratio CDR = 3.98
Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Dimensioning No. 1

Active pressure distribution behind the structure (without surcharge)

Layer No.	Start [ft] End [ft]	σ_z [psf]	σ_w [psf]	Pressure [psf]	Hor. comp. [psf]	Vert. comp. [psf]
1	0.00	0.0	0.0	0.0	0.0	0.0
	0.50	55.0	0.0	11.9	11.3	3.9
2	0.50	55.0	0.0	10.1	9.9	2.4
	3.62	398.3	0.0	73.5	71.3	17.6
3	3.62	398.3	0.0	216.1	94.7	194.3
	6.50	715.0	0.0	388.0	170.1	348.7
4	6.50	715.0	0.0	388.0	170.1	348.7
	8.00	880.0	0.0	477.5	209.3	429.2
5	8.00	880.0	0.0	191.1	180.7	62.2
	9.50	1044.8	0.0	226.9	214.5	73.9
6	9.50	1044.8	0.0	0.0	0.0	0.0
	9.50	1045.1	0.0	0.0	0.0	0.0

Forces acting on construction

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0.0	-4.28	3590.6	1.94	0.900	0.900	1.250
Weight - earth wedge	0.0	-3.22	448.9	3.60	1.000	1.000	1.350
Active pressure	1091.3	-3.12	1499.2	4.11	1.500	0.900	1.500
Traffic	294.7	-4.14	272.4	3.94	1.500	1.500	1.500

Verification of block No. 1

Check for overturning stability
Resisting moment M_{res} = 16840.5 lbfft/ft
Overturning moment M_{ovr} = 6939.8 lbfft/ft

Capacity demand ratio CDR = 2.43
Joint for overturning stability is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 3824.00 lbf/ft
Active horizontal force H_{act} = 1424.21 lbf/ft

Capacity demand ratio CDR = 2.68
Joint for verification is SATISFACTORY

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Bearing capacity of foundation soil

Design load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]	Eccentricity [–]	Stress [psf]
1	2727.8	8605.33	2079.79	0.053	1603.7
2	2897.7	6960.48	2079.79	0.069	1347.0

Service load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]
1	1785.3	6490.22	1386.52

Verification of foundation soil

Stress in the footing bottom : trapezoid

Eccentricity verification

Max. eccentricity of normal force e = 0.069
Maximum allowable eccentricity e_{alw} = 0.333

Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity

Ultimate bearing capacity of found. soil	R	=	20000.0	psf
Partial factor on bearing capacity	γ_{Rv}	=	0.45	
Max. stress at footing bottom	σ	=	1888.8	psf
Allowable bearing capacity of foundation soil	R_d	=	9000.0	psf
Capacity demand ratio	CDR	=	4.8	

Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

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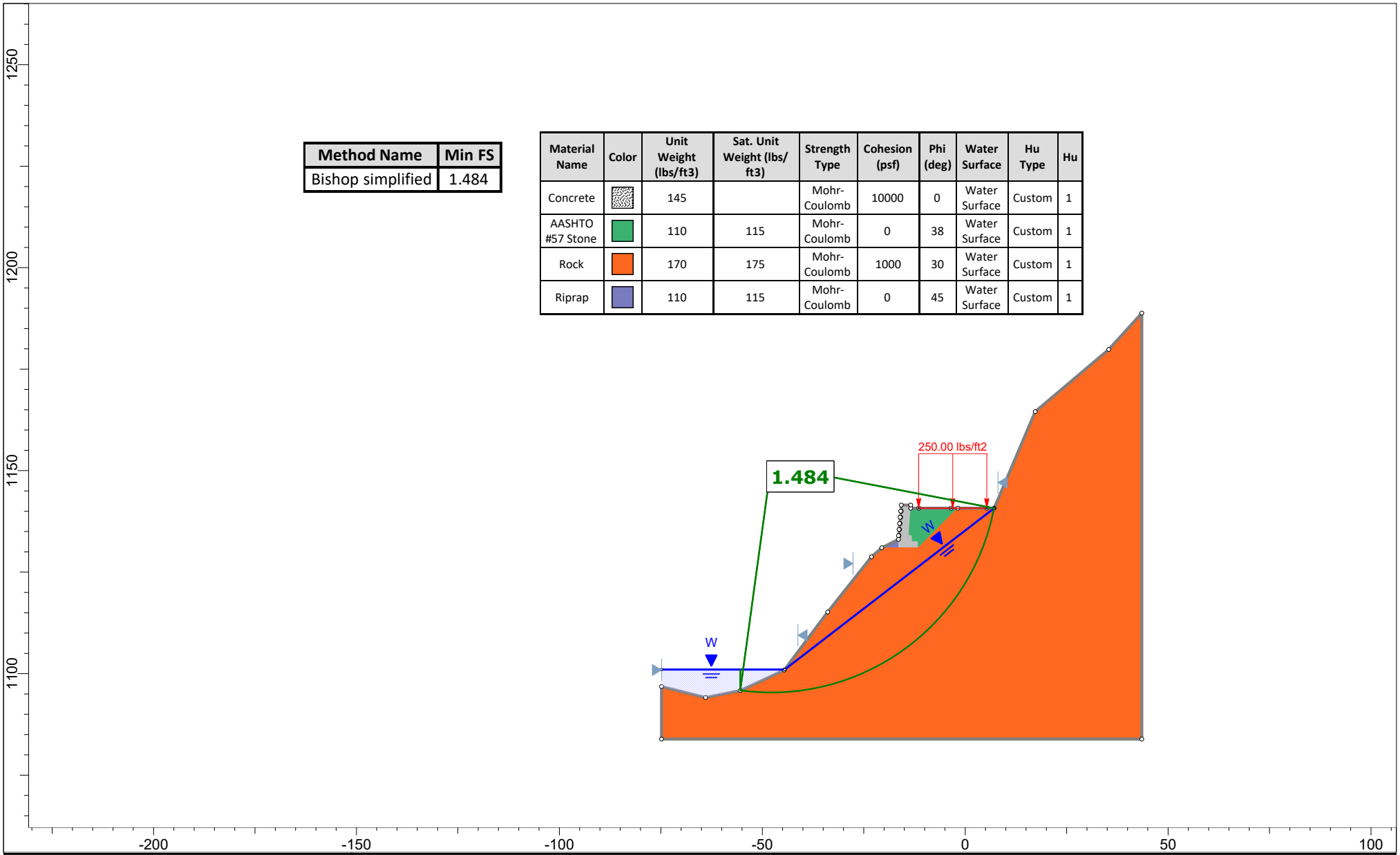
Method Name	Min FS
Bishop simplified	1.484

Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Concrete		145		Mohr-Coulomb	10000	0	Water Surface	Custom	1
AASHTO #57 Stone		110	115	Mohr-Coulomb	0	38	Water Surface	Custom	1
Rock		170	175	Mohr-Coulomb	1000	30	Water Surface	Custom	1
Riprap		110	115	Mohr-Coulomb	0	45	Water Surface	Custom	1

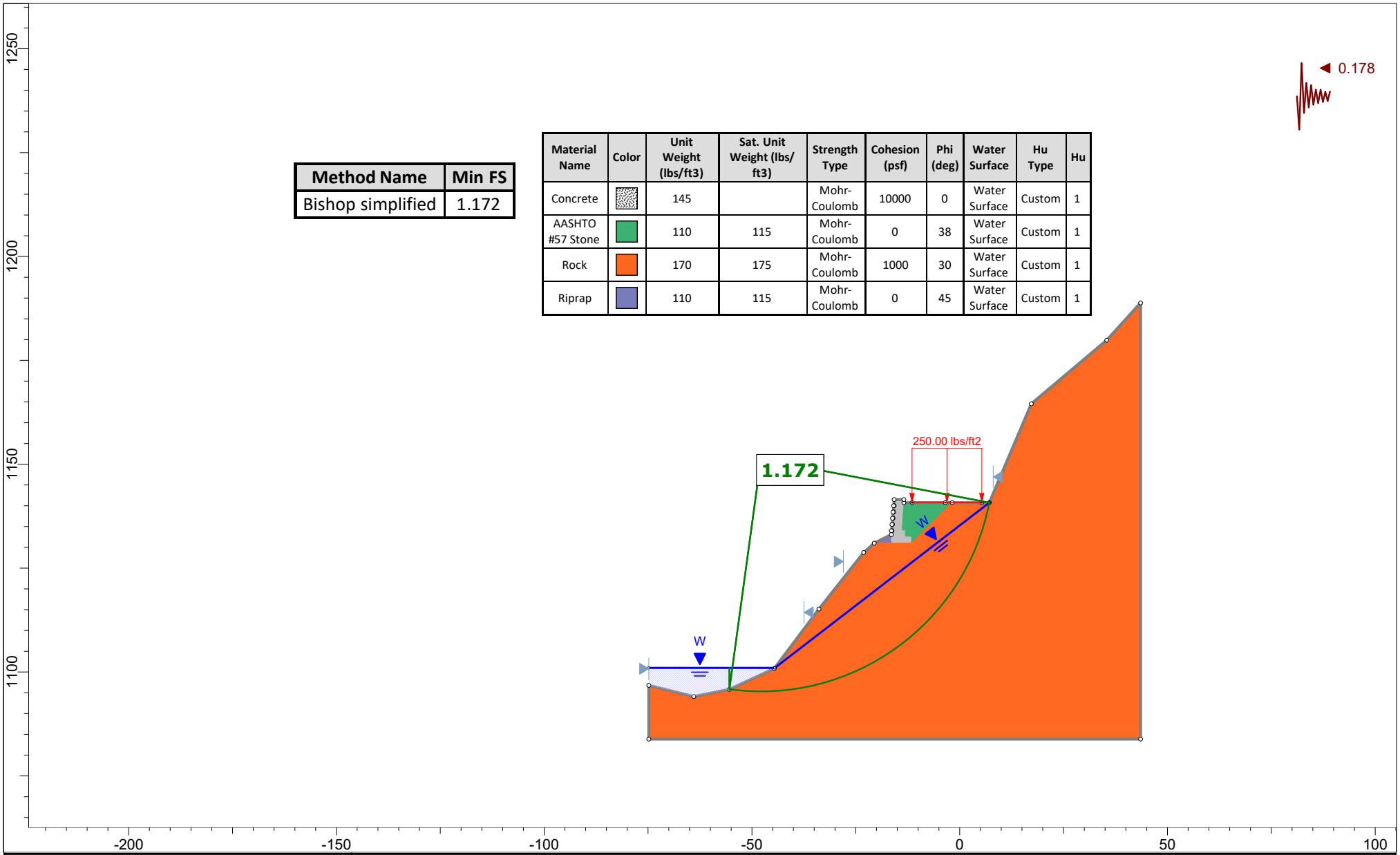


SLIDEINTERPRET 9.022

Project	McFarland Road FS 23 - P370: MP 10. 189		
Group	Group 1	*Scenario*	Master Scenario
Drawn By	SY	*Company*	JMT
Date	12/08/2023, 11:36:25 AM	*File Name*	Redirock Wall P370.slmd

Method Name	Min FS
Bishop simplified	1.172

Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Concrete		145		Mohr-Coulomb	10000	0	Water Surface	Custom	1
AASHTO #57 Stone		110	115	Mohr-Coulomb	0	38	Water Surface	Custom	1
Rock		170	175	Mohr-Coulomb	1000	30	Water Surface	Custom	1
Riprap		110	115	Mohr-Coulomb	0	45	Water Surface	Custom	1

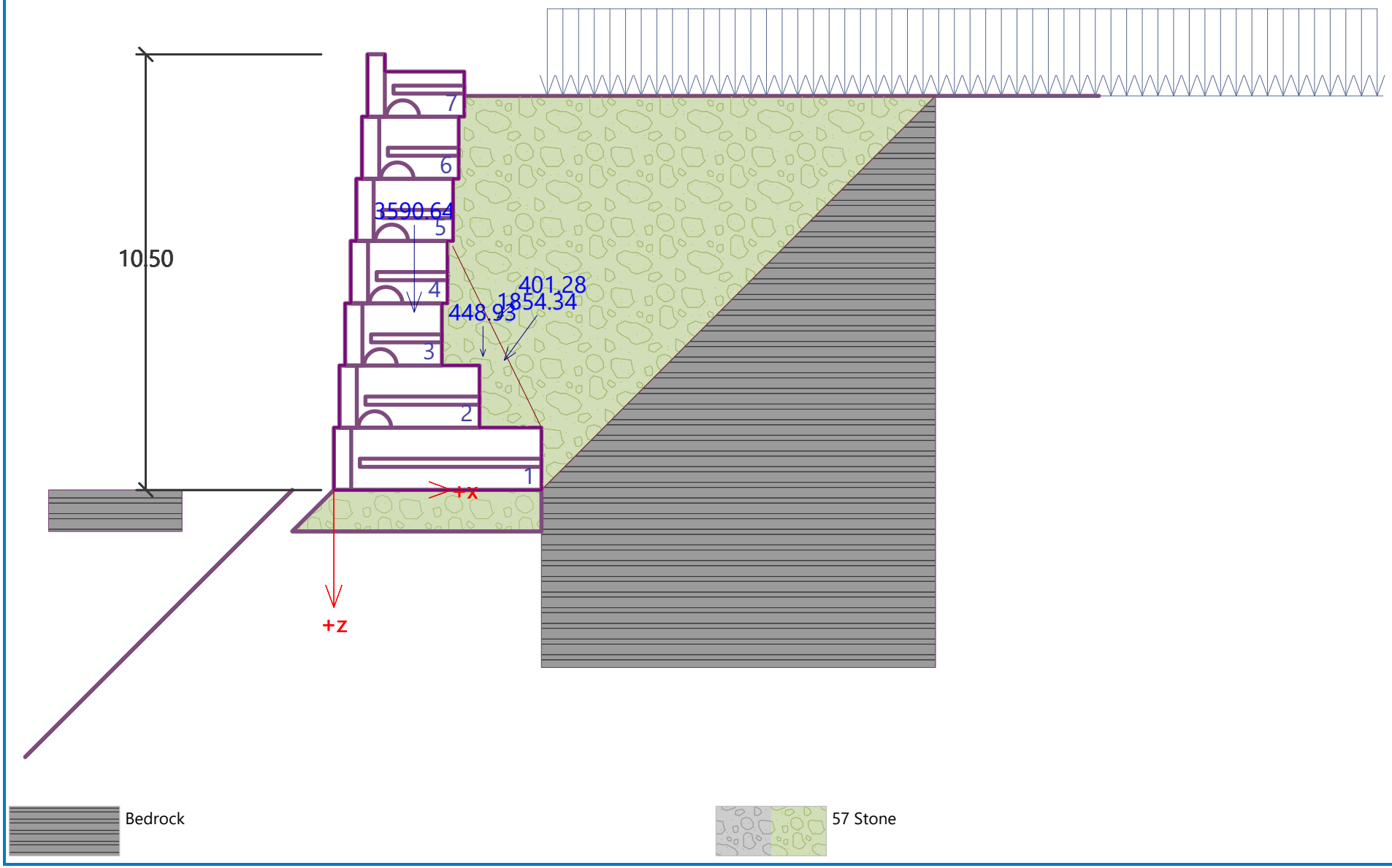


Project	McFarland Road FS 23 - P370: MP 10. 189		
Group	Group 1	Scenario	Scenario with Seismic Load
Drawn By	SY	Company	JMT
Date	12/08/2023, 11:36:25 AM	File Name	Redirock Wall P370.slmd

SLIDEINTERPRET 9.022

MP 10.378 Wall
(P 371)

Name : | **Stage - analysis : 1 - 1**



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Analysis of Redi Rock wall

Input data

Project : McFarland Rd (FS23)
Part : MP10.378 (P371)
Customer : EFLHD
Author : VKG
Date : 5/6/2024
Project number : 19-01472-007

Settings

(input for current task)

Wall analysis

Verification methodology : according to LRFD
Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : Mononobe-Okabe
Shape of earth wedge : Calculate as skew
Allowable eccentricity : 0.333
Internal stability : Standard - straight slip surface
Reduction coeff. of contact first block - base : 1.00

Load factors					
Design situation - Strength I					
		Minimum		Maximum	
Dead load of structural components :	DC =	0.90	[–]	1.25	[–]
Dead load of wearing surfaces :	DW =	0.65	[–]	1.50	[–]
Earth pressure - active :	EH_A =	0.90	[–]	1.50	[–]
Earth pressure - at rest :	EH_R =	0.90	[–]	1.35	[–]
Earth surcharge load (permanent) :	ES =	0.75	[–]	1.50	[–]
Vertical pressure of earth fill :	EV =	1.00	[–]	1.35	[–]
Live load surcharge :	LL =	0.00	[–]	1.75	[–]
Water load :	WA =	1.00	[–]	1.00	[–]

Resistance factors			
Design situation - Strength I			
Resistance factor on overturning :	ϕ_o =	0.90	[–]
Resistance factor on sliding :	ϕ_t =	0.90	[–]
Resistance factor on bearing capacity :	ϕ_b =	0.45	[–]
Resistance factor on passive pressure :	ϕ_{VE} =	0.50	[–]

Blocks

No.	Description	Height h [in]	Width w [in]	Unit weight γ [pcf]
1	Block 28	18.00	28.00	120.00
2	Block 41	18.00	40.50	120.00
3	Block 60	18.00	60.00	130.00
4	Top block 24 straight	18.00	24.00	108.00
5	Planter 41	18.00	40.50	120.00

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No.	Description	Height h [in]	Width w [in]	Unit weight γ [pcf]
6	Planter 60	18.00	60.00	112.00
7	Top block 28	18.00	28.00	120.00
8	Top block 41	18.00	40.50	120.00
9	Top block 24 straight garden	18.00	24.00	80.00
10	Block R-5236 HC	36.00	52.00	110.00
11	Block R-7236 HC	36.00	72.00	110.00
12	Block R-9636 HC	36.00	96.00	110.00
13	Block R-41 HC	18.00	40.50	110.00

No.	Description	Min. shear strength F_{min} [lbf/ft]	Max. shear strength F_{max} [lbf/ft]	Friction f [°]
1	Block 28	6061.00	11276.00	44.00
2	Block 41	6061.00	11276.00	44.00
3	Block 60	6061.00	11276.00	44.00
4	Top block 24 straight	6061.00	11276.00	44.00
5	Planter 41	6061.00	11276.00	44.00
6	Planter 60	6061.00	11276.00	44.00
7	Top block 28	6061.00	11276.00	44.00
8	Top block 41	6061.00	11276.00	44.00
9	Top block 24 straight garden	6061.00	11276.00	44.00
10	Block R-5236 HC	4550.00	12000.00	44.00
11	Block R-7236 HC	4550.00	12000.00	44.00
12	Block R-9636 HC	4550.00	12000.00	44.00
13	Block R-41 HC	5358.00	12906.00	37.00

Setbacks

No.	Setback s [in]
1	0.010
2	0.375
3	1.625
4	9.375
5	16.625

Geometry

No. group	Description	Count	Setback s [in]
1	Block 60	1	1.62
2	Block 41	1	1.62
3	Block 28	4	1.62
4	Top block 28	1	-

Base

Geometry

Upper setback a_1 = 0.00 ft

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Lower setback a_2 = 1.00 ft
Height h = 1.00 ft
Width b = 6.00 ft

Material
Soil creating foundation - 57 Stone

Basic soil parameters

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [psf]	γ [pcf]	γ_{su} [pcf]	δ [°]
1	57 Stone		38.00	0.0	110.00	52.50	19.00
2	Bedrock		30.00	1000.0	165.00	107.50	15.00

All soils are considered as cohesionless for at rest pressure analysis.

Soil parameters

57 Stone
Unit weight : γ = 110.0 pcf
Stress-state : effective
Angle of internal friction : φ_{ef} = 38.00 °
Cohesion of soil : c_{ef} = 0.0 psf
Angle of friction struc.-soil : δ = 19.00 °
Saturated unit weight : γ_{sat} = 115.0 pcf

Bedrock
Unit weight : γ = 165.0 pcf
Stress-state : effective
Angle of internal friction : φ_{ef} = 30.00 °
Cohesion of soil : c_{ef} = 1000.0 psf
Angle of friction struc.-soil : δ = 15.00 °
Saturated unit weight : γ_{sat} = 170.0 pcf

Backfill

Assigned soil : 57 Stone
Slope = 45.00 °

Geological profile and assigned soils

Position information
Terrain elevation = 1029.00 ft

Geological profile and assigned soils

No.	Thickness of layer t [ft]	Depth z [ft]	Elevation [ft]	Assigned soil	Pattern
1	14.00	0.00 .. 14.00	1029.00 .. 1015.00	Bedrock	
2	33.50	14.00 .. 47.50	1015.00 .. 981.50	Bedrock	
3	-	47.50 .. ∞	981.50 .. -	Bedrock	

Terrain profile

Terrain behind the structure is flat.

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Depth of terrain below the top of wall h = 1.00 ft.

Water influence

Ground water table is located below the structure.

Input surface surcharges

No.	Surcharge new	Surcharge change	Action	Mag.1 [lbf/ft²]	Mag.2 [lbf/ft²]	Ord.x x [ft]	Length l [ft]	Depth z [ft]
1	Yes		permanent	250.00		2.00	20.00	on terrain

No.	Name
1	Traffic

Resistance on front face of the structure

Resistance on front face of the structure: not considered
Soil on front face of the structure - Bedrock
Soil thickness in front of structure h = 1.00 ft
Soil slope in front of structure β = -45.00 °

Settings of the stage of construction

Design situation : Strength I
Reduction of soil/soil friction angle : do not reduce

Verification No. 1

Active pressure distribution behind the structure (without surcharge)

Layer No.	Start [ft] End [ft]	σ_z [psf]	σ_w [psf]	Pressure [psf]	Hor. comp. [psf]	Vert. comp. [psf]
1	0.00	0.0	0.0	0.0	0.0	0.0
	0.50	55.0	0.0	11.9	11.3	3.9
2	0.50	55.0	0.0	10.1	9.9	2.4
	3.62	398.3	0.0	73.5	71.3	17.6
3	3.62	398.3	0.0	216.1	94.7	194.3
	6.50	715.0	0.0	388.0	170.1	348.7
4	6.50	715.0	0.0	388.0	170.1	348.7
	8.00	880.0	0.0	477.5	209.3	429.2
5	8.00	880.0	0.0	191.1	180.7	62.2
	9.50	1045.0	0.0	226.9	214.6	73.9
6	9.50	1045.0	0.0	0.0	0.0	0.0
	10.50	1210.0	0.0	0.0	0.0	0.0

Forces acting on construction

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0.0	-4.54	4250.6	2.95	0.900	0.900	1.250
Weight - earth wedge	0.0	-4.22	448.9	4.60	1.000	1.000	1.350
Active pressure	1091.7	-4.12	1499.4	5.11	1.500	1.500	1.500
Traffic	294.8	-5.13	291.3	5.01	1.500	1.500	1.500

Verification of complete wall

Check for overturning stability

Resisting moment M_{res} = 24303.0 lbfft/ft
Overturning moment M_{ovr} = 9019.6 lbfft/ft

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Capacity demand ratio CDR = 2.69
Wall for overturning is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 8267.43 lbf/ft
Active horizontal force H_{act} = 2079.79 lbf/ft

Capacity demand ratio CDR = 3.98
Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Dimensioning No. 1

Active pressure distribution behind the structure (without surcharge)

Layer No.	Start [ft] End [ft]	σ_z [psf]	σ_w [psf]	Pressure [psf]	Hor. comp. [psf]	Vert. comp. [psf]
1	0.00	0.0	0.0	0.0	0.0	0.0
	0.50	55.0	0.0	11.9	11.3	3.9
2	0.50	55.0	0.0	10.1	9.9	2.4
	3.62	398.3	0.0	73.5	71.3	17.6
3	3.62	398.3	0.0	216.1	94.7	194.3
	6.50	715.0	0.0	388.0	170.1	348.7
4	6.50	715.0	0.0	388.0	170.1	348.7
	8.00	880.0	0.0	477.5	209.3	429.2
5	8.00	880.0	0.0	191.1	180.7	62.2
	9.50	1044.8	0.0	226.9	214.5	73.9
6	9.50	1044.8	0.0	0.0	0.0	0.0
	9.50	1045.1	0.0	0.0	0.0	0.0

Forces acting on construction

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0.0	-4.28	3590.6	1.94	0.900	0.900	1.250
Weight - earth wedge	0.0	-3.22	448.9	3.60	1.000	1.000	1.350
Active pressure	1091.3	-3.12	1499.2	4.11	1.500	0.900	1.500
Traffic	294.7	-4.14	272.4	3.94	1.500	1.500	1.500

Verification of block No. 1

Check for overturning stability
Resisting moment M_{res} = 16840.5 lbfft/ft
Overturning moment M_{ovr} = 6939.8 lbfft/ft

Capacity demand ratio CDR = 2.43
Joint for overturning stability is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 3824.00 lbf/ft
Active horizontal force H_{act} = 1424.21 lbf/ft

Capacity demand ratio CDR = 2.68
Joint for verification is SATISFACTORY

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Bearing capacity of foundation soil

Design load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]	Eccentricity [–]	Stress [psf]
1	2727.8	8605.33	2079.79	0.053	1603.7
2	2897.7	6960.48	2079.79	0.069	1347.0

Service load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]
1	1785.3	6490.22	1386.52

Verification of foundation soil

Stress in the footing bottom : trapezoid

Eccentricity verification

Max. eccentricity of normal force e = 0.069
Maximum allowable eccentricity e_{alw} = 0.333

Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity

Ultimate bearing capacity of found. soil	R	=	20000.0	psf
Partial factor on bearing capacity	γ_{Rv}	=	0.45	
Max. stress at footing bottom	σ	=	1888.8	psf
Allowable bearing capacity of foundation soil	R_d	=	9000.0	psf
Capacity demand ratio	CDR	=	4.8	

Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

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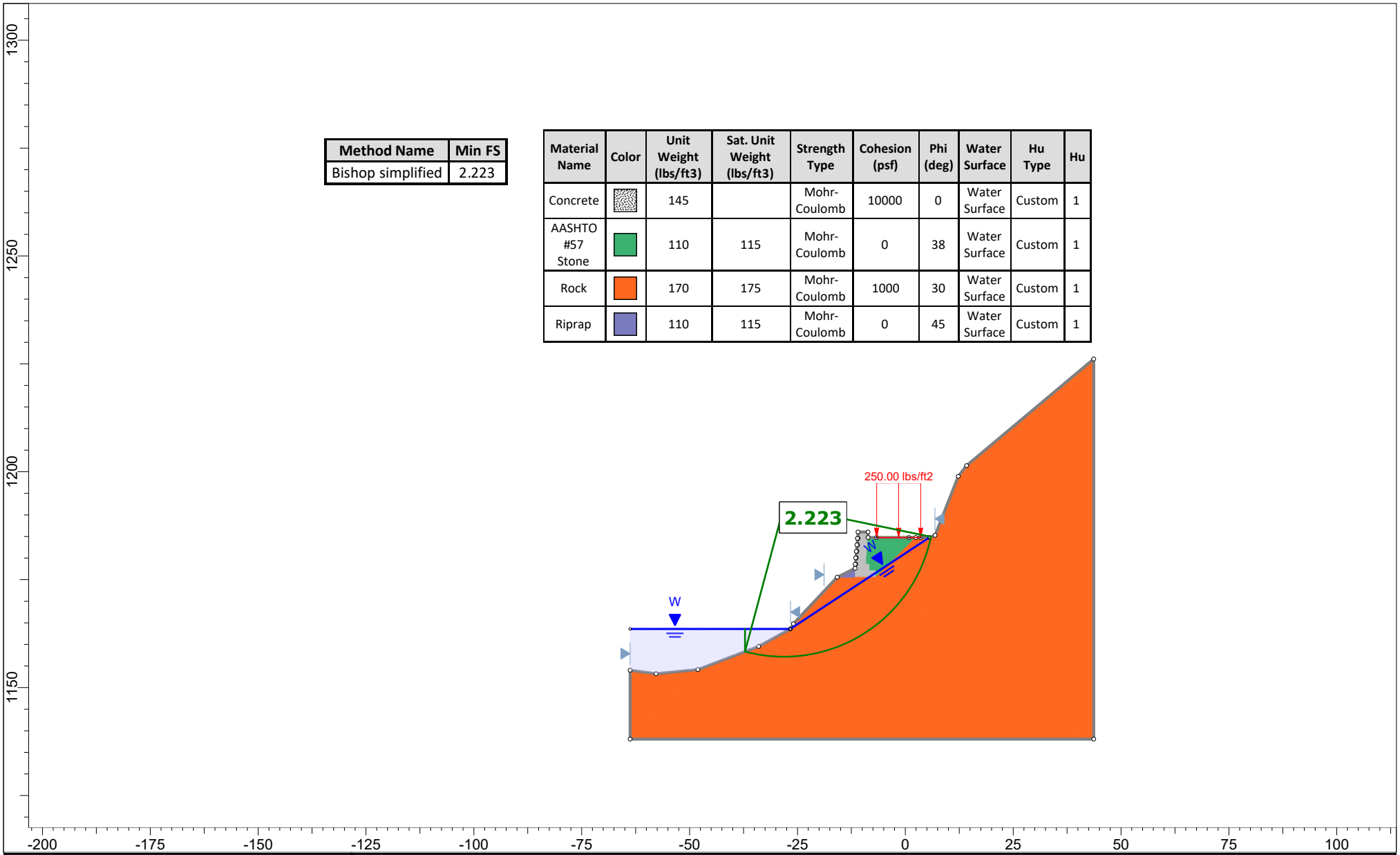
Method Name	Min FS
Bishop simplified	2.223

Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Concrete		145		Mohr-Coulomb	10000	0	Water Surface	Custom	1
AASHTO #57 Stone		110	115	Mohr-Coulomb	0	38	Water Surface	Custom	1
Rock		170	175	Mohr-Coulomb	1000	30	Water Surface	Custom	1
Riprap		110	115	Mohr-Coulomb	0	45	Water Surface	Custom	1

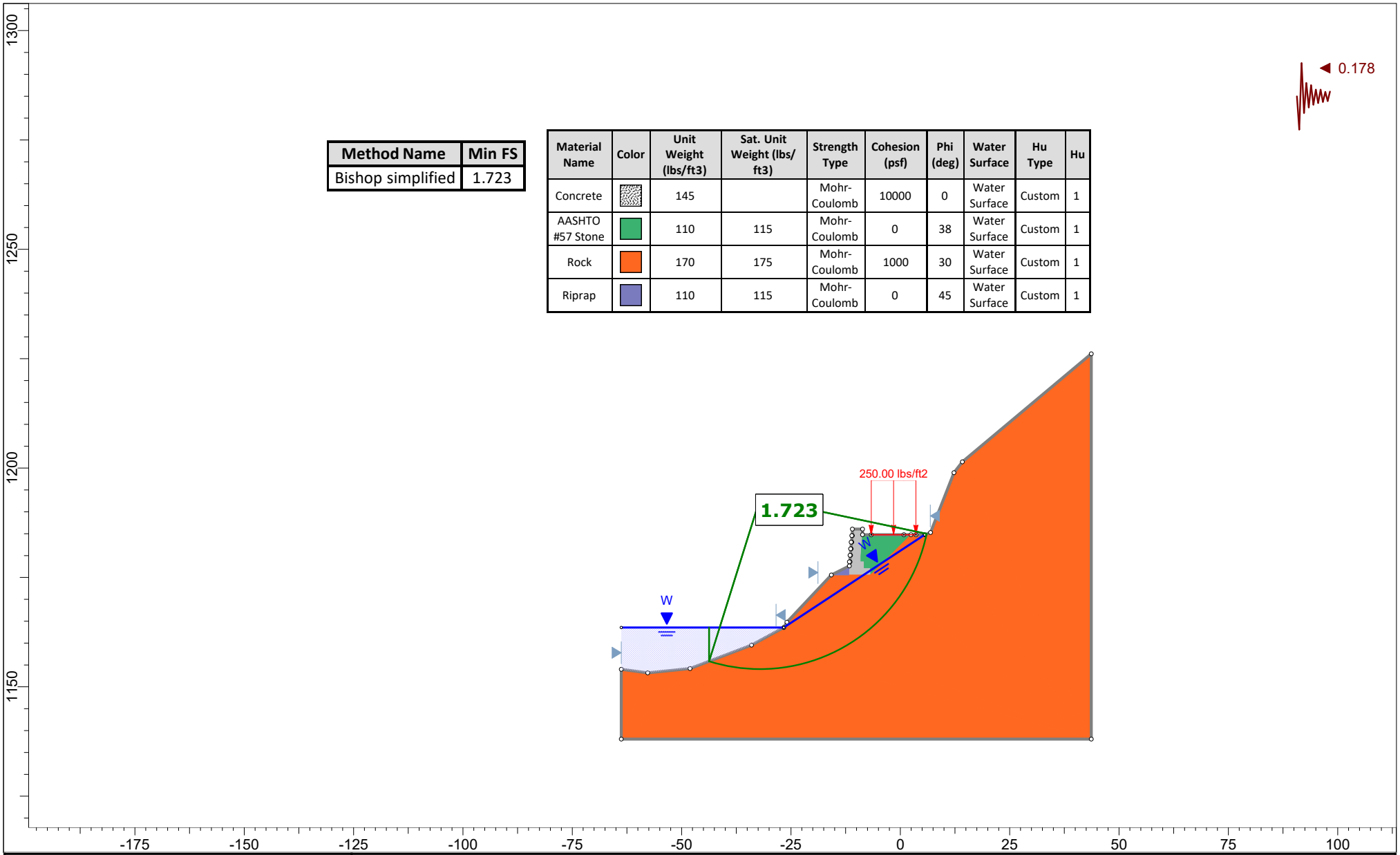


Project	McFarland Road FS 23 - P371 : MP 10.378		
Group	Group 1	Scenario	Master Scenario
Drawn By	SY	Company	JMT
Date	12/08/2023, 11:36:25 AM	File Name	Redirock Wall P371.slmd

SLIDEINTERPRET 9.022

Method Name	Min FS
Bishop simplified	1.723

Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Concrete		145		Mohr-Coulomb	10000	0	Water Surface	Custom	1
AASHTO #57 Stone		110	115	Mohr-Coulomb	0	38	Water Surface	Custom	1
Rock		170	175	Mohr-Coulomb	1000	30	Water Surface	Custom	1
Riprap		110	115	Mohr-Coulomb	0	45	Water Surface	Custom	1



SLIDEINTERPRET 9.022

Project	McFarland Road FS 23 - P371 : MP 10.378		
Group	Group 1	Scenario	Scenario with Seismic Load
Drawn By	SY	Company	JMT
Date	12/08/2023, 11:36:25 AM	File Name	Redirock Wall P371.slmd