GEOTECHNICAL DESIGN REPORT

US-395 G-1092 AND I-1093 MSE ABUTMENT WALLS
RENO, NEVADA

EA 74107

JANUARY 2023

| **NEVADA DEPARTMENT OF TRANSPORTATION** | MATERIALS DIVISION |
| GEOTECHNICAL SECTION | 1263 STEWART ST, CARSON CITY, NEVADA 89712 |

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION
GEOTECHNICAL SECTION

GEOTECHNICAL DESIGN REPORT

US-395 G-1092 & I-1093 MSE ABUTMENT WALLS

RENO, NEVADA

JANUARY 2023

EA 74107

Prepared by: ______________________________
George Helgerson, P.E.
Geotechnical Engineer

Reviewed by: ______________________________
Kyle Jermstad, P.E.
Principal Geotechnical Engineer

Reviewed by: ______________________________
Mike Griswold, P.E.
Chief Geotechnical Engineer

Contents

1. Introduction 1
1.1 Project Description 1
1.2 Purpose and Scope of Work.. 1
1.3 Limitations.. 1
2. Field Exploration and Site/Subsurface Exploration 2
3. MSE Wall Recommendations 3
3.1 General 3
3.1.1 External Stability 3
3.1.2 Global Stability 3
4. References 6

Table Index

Table 1 Strength Parameters for MSE Walls............ **Error! Bookmark not defined.**
Table 2 MSE Wall Portions Perpendicular to Mainline Design Results**Error! Bookmark not defined.**
Table 3 MSE Wall Portions Parallel to Mainline Design Results 5

Appendices

A Global Stability Results
B External Stability Results

1. Introduction

The Nevada Department of Transportation (NDOT) plans to widen US395 from Clear Acre Lane to Golden Valley Interchange. This report presents the recommendations for mechanically stabilized earth (MSE) walls supporting G-1092 and I-1093 bridge approach slabs. These recommendations were developed using NewFields' "Geotechnical Design Report Phase 1B: US395 North Valleys Washoe County, NV 2020" for the proposed widening project.

1.1 Project Description

It is our understanding that this portion of the project consists of constructing 4 MSE walls: RW16, RW17, RW18, and RW19. These MSE walls will support the new bridge approach slabs. RW16 & RW17 are located on the south and north side, respectively, of G-1092 (Panther Valley UPRR Bridge). RW18 & RW19 are located on the south and north side, respectively, of I-1093 (Panther Valley Interchange Bridge).

1.2 Purpose and Scope of Work

The purpose of this report is to evaluate the suitability of the project site from a geotechnical perspective, for the proposed retaining walls. The main objectives of the analysis were to perform engineering analyses, develop geotechnical recommendations for design and construction, and document our findings and recommendations in this report.

The scope of our geotechnical design includes the following:

- Perform engineering analyses to develop geotechnical design criteria and recommendations for the proposed project
- Preparation of this report

1.3 Limitations

This report has been prepared by Nevada Department of Transportation (NDOT) Geotechnical Section under the supervision of those whose signatures appear herein. The interpretation of data, findings, and recommendations presented in this report were developed from a consultant's geotechnical investigation.

If the proposed project is modified or relocated, or if the subsurface conditions found during construction differ from those described in this report, NDOT Geotechnical Section should be contacted immediately to assess the new information or changed conditions and determine if additional recommendations are required.

2. Field Exploration and Site/Subsurface Exploration

The geotechnical exploration was conducted by NewFields and completed in August of 2020. The report is titled *Geotechnical Design Report Phase 1B: US395 North Valleys Washoe County, Nevada* and can be found in the contract documents and on the NDOT website.

3. MSE Wall Recommendations

3.1 General

Design recommendations for the proposed MSE retaining walls RW-16, RW-17, RW-18, and RW-19 are included. The proposed MSE walls vary in height from a minimum of about 10 feet to a maximum of approximately 32 feet. External stability analysis was performed for each wall in accordance with AASHTO 2020 including sliding, bearing resistance, overall global stability, and eccentricity. The walls were also evaluated at the service limit state for settlement.

The minimum length of soil reinforcement for MSE walls perpendicular to mainline is 70 percent of the wall height as measured from the leveling pad. Portions of the MSE walls which are parallel to the mainline have a minimum reinforcement length of 110 percent of the wall (see project plans for details). In no case should the minimum reinforcement length be less than 8 feet.

A minimum embedment depth to the bottom of the reinforced soil mass (top of leveling pad) should be 2 feet for level top and toe slopes. The minimum embedment depth for walls constructed with 1.5H:1V toe slopes should be 4.5 feet.

Resistance factors for MSE walls on this project were designed using a sliding resistance factor of 1.0 and a bearing resistance factor of 0.65 for the Strength Limit State.

An evaluation of internal stability or compound global stability of the MSE walls was not included in our investigation. An assessment of the internal stability and compound global stability will be required by the MSE wall designer or a qualified geotechnical engineer during the design of the walls per Section 642 of the Special Provisions.

3.1.1 External Stability

An external stability analysis was performed for each wall. The failure mechanisms of sliding, bearing resistance and eccentricity were evaluated using the computer software program MSEW 3.0 (ADAMA Engineering 2019). The length of soil reinforcement required to meet the capacity demand ratio for each failure mechanism was determined in accordance with AASHTO LRFD (2020 edition) Bridge Design Articles 11.10.4 and 11.10.5. The results of the analysis are presented in Appendix B. Based upon our analysis, the walls meet the minimum capacity demand ratios for each failure mechanism provided the walls are constructed in accordance with the Specifications and the recommendations herein.

3.1.2 Global Stability

The overall global stability of the retaining walls was analyzed using Slide 2018 (Rocscience version 8.0). This software program evaluated each retaining wall using the two-dimensional limiting equilibrium method. The purpose of the analysis was to identify potential failure planes and to derive factors of safety for each wall configuration. A seismic load of 0.25g horizontal acceleration was used in the seismic analysis, and a traffic surcharge load of 250 psf was added to the top of each wall. The 0.25g is one half of the PGA of 0.5g for the site.

Both the Spencer and the Modified Bishop method of slices were used in the program. The Spencer method considers both the moment and force equilibrium of each slice, whereas the Modified Bishop considers the vertical equilibrium of each slice. Compound failure (where failure surfaces pass through portions of the reinforced soil mass) was not considered in the scope of this report but will be evaluated by the wall designer as part of the internal stability analysis. Consequently, the strength parameters in the reinforced soil zone were set to infinite strength to force the failure surfaces outside the reinforced soil zone. Shear strengths in the retained and foundation soil zones are based on the Mohr-Coulomb strength parameters using the results of our laboratory testing. The following table summarizes the strength parameters used for the MSE walls:

Table 1: Strength Parameters for MSE Walls

Material	Moist Unit Weight (pcf)	Friction Angle, ϕ (degrees)	Cohesion, c (psf)
Reinforced Soil	135	Infinite Strength	Infinite Strength
Retained Soil	125	34	0
Foundation Soil (Native)	120	35	100

The results of the global stability analysis revealed that all the walls perpendicular to mainline are stable with the minimum reinforcement length of 0.7H. A minimum length of 1.1H is required for walls parallel to mainline to achieve a minimum factor of safety of 1.5 for static, 1.1 for pseudo-static, and 1.2 for the temporary construction condition. The walls parallel to mainline require a larger reinforcement length due to the proposed toe slopes. Based upon the above criteria, the following table summarizes the results of the analysis:

Table 2: MSE Wall Portions Perpendicular to Mainline Design Results

Bridge	MSE Wall ID	Foundation Soil	Maximum Wall Height (ft)	Minimum Reinforcement Length for Maximum Wall Height Section (ft)	Static Global Stability Factor of Safety (FS)	Pseudo-Static Global Factor of Safety (FS)
G-1092	RW-16	Native	30	21	2.0	1.3
G-1092	RW-17	Native	30	21	2.0	1.3
I-1093	RW-18	Native	26	18.2	2.1	1.3
I-1093	RW-19	Native	32	22.4	2.1	1.3

Table 3: MSE Wall Portions Parallel to Mainline Design Results

Bridge	MSE Wall ID	Foundation Soil	Maximum Wall Height (ft)	Minimum Reinforcement Length for Maximum Wall Height Section (ft)	Static Global Stability Factor of Safety (FS)	Pseudo-Static Global Factor of Safety (FS)
G-1092	RW-16	Native/Fill	28	30.8	1.9	1.2
	RW-17	Native/Fill	22	24.2	2.0	1.2
I-1093	RW-18	Native/Fill	26	28.6	1.8	1.1
	RW-19	Native/Fill	30	33	1.7	1.1

4. References

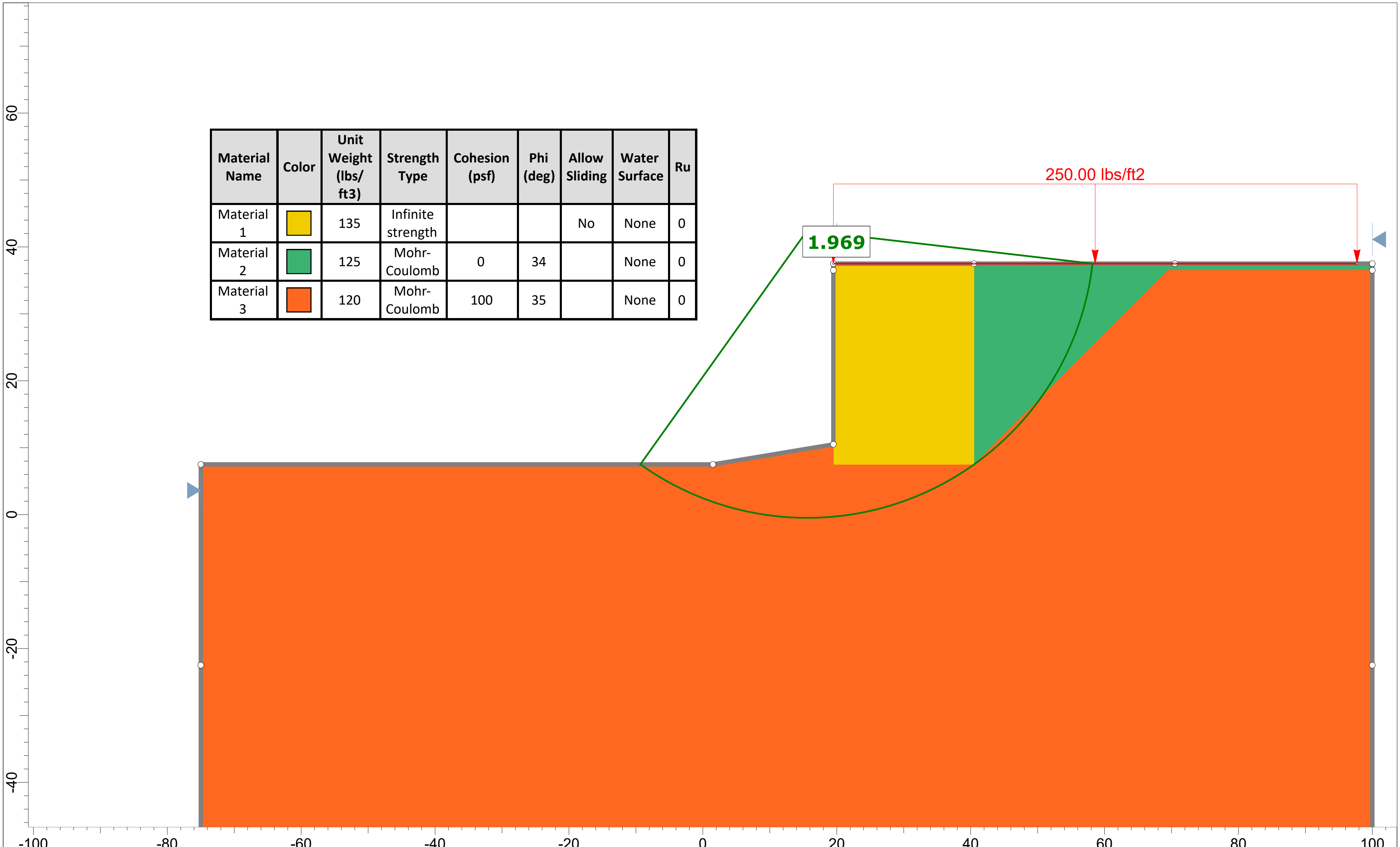
American Association of State Highway and Transportation Officials (AASHTO), 2020, “LRFD Bridge Design Specifications, 9th Edition”

Nevada Department of Transportation (NDOT), 2014, “Standard Specifications for Road and Bridge Construction”

NewFields, 2020, “Geotechnical Design Report Phase 1B: US395 North Valleys Washoe County, Nevada”

Rocscience, Inc., SLIDE Version 8.0, 54 Saint Patrick St., Toronto, Ontario, Canada

Appendix A
Global Stability Results



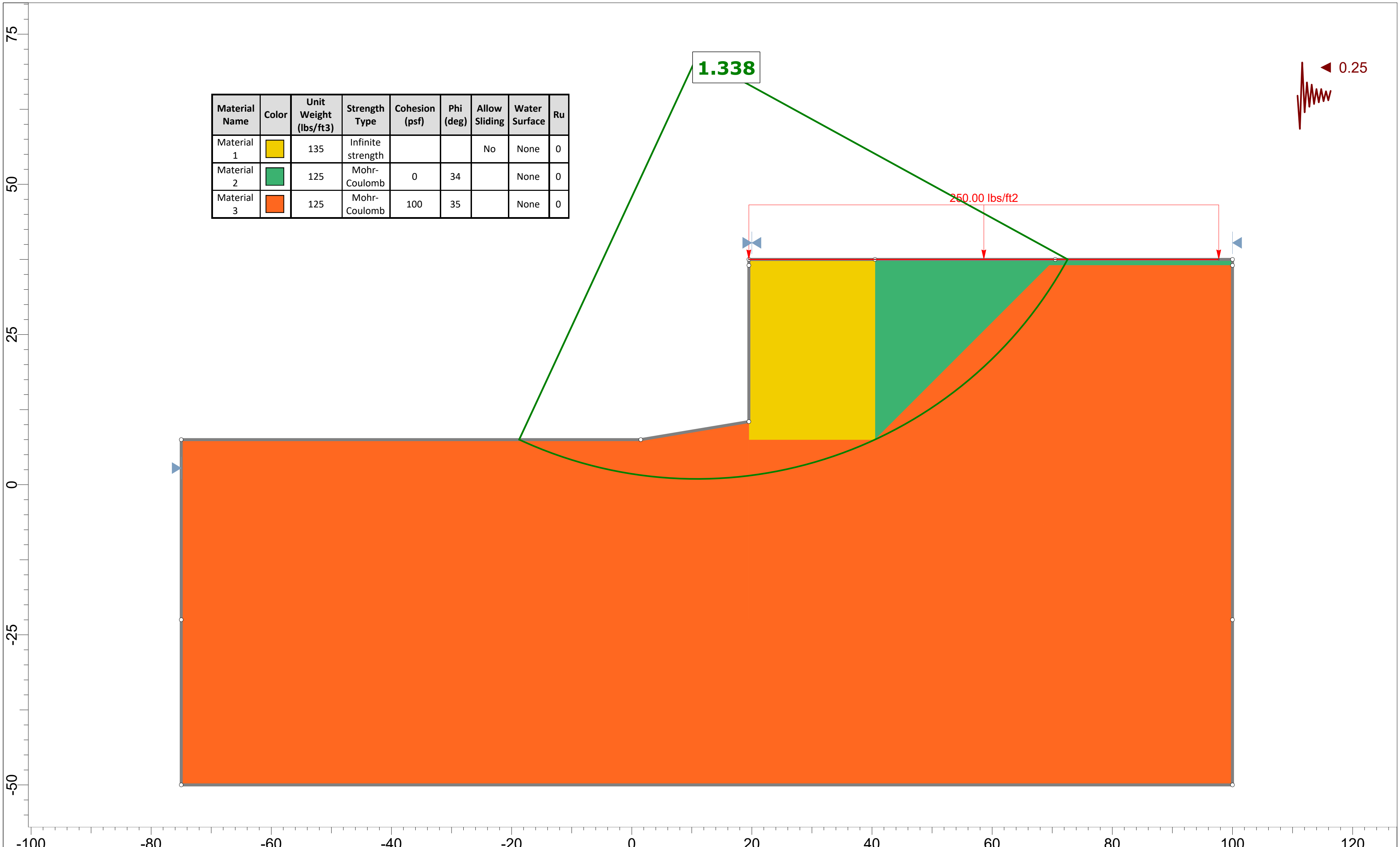
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Allow Sliding	Water Surface	Ru
Material 1	Yellow	135	Infinite strength			No	None	0
Material 2	Green	125	Mohr-Coulomb	0	34		None	0
Material 3	Orange	120	Mohr-Coulomb	100	35		None	0

rocscience

SLIDEINTERPRET 9.019

Project SLIDE - An Interactive Slope Stability Program	
Group Group 1	*Scenario* Master Scenario
Drawn By	*Company*
Date 6/13/2022, 1:58:23 PM	*File Name* G-1092 - Perpendicular Main Section Static.slmd

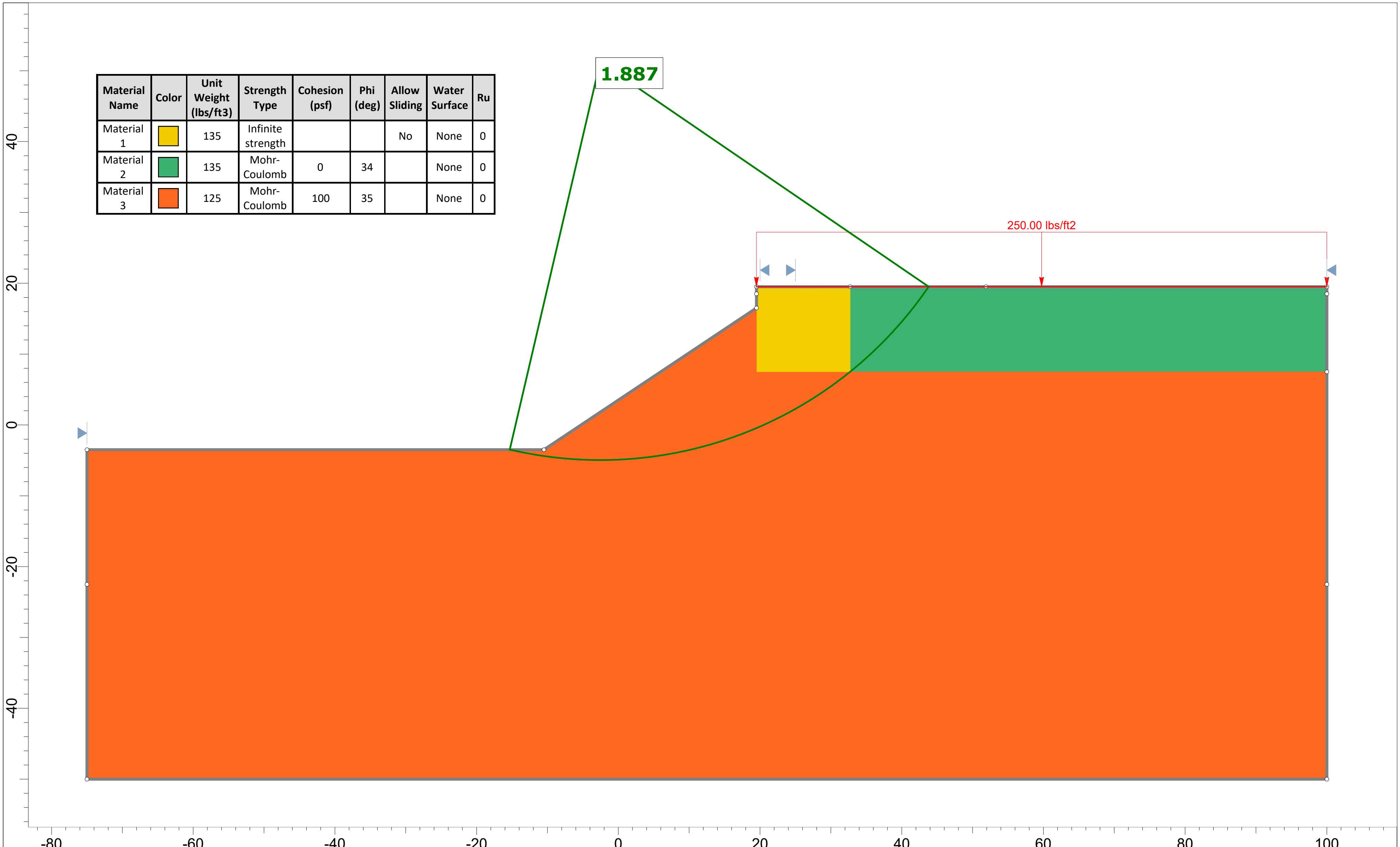
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Allow Sliding	Water Surface	Ru
Material 1		135	Infinite strength			No	None	0
Material 2		125	Mohr-Coulomb	0	34		None	0
Material 3		125	Mohr-Coulomb	100	35		None	0



Project	SLIDE - An Interactive Slope Stability Program		
Group	Group 1	*Scenario*	Master Scenario
Drawn By		*Company*	
Date	6/13/2022, 1:58:23 PM	*File Name*	G-1092 - Perpendicular Main Section Pseudo-Static.slmd

rocscience

SLIDEINTERPRET 9.019

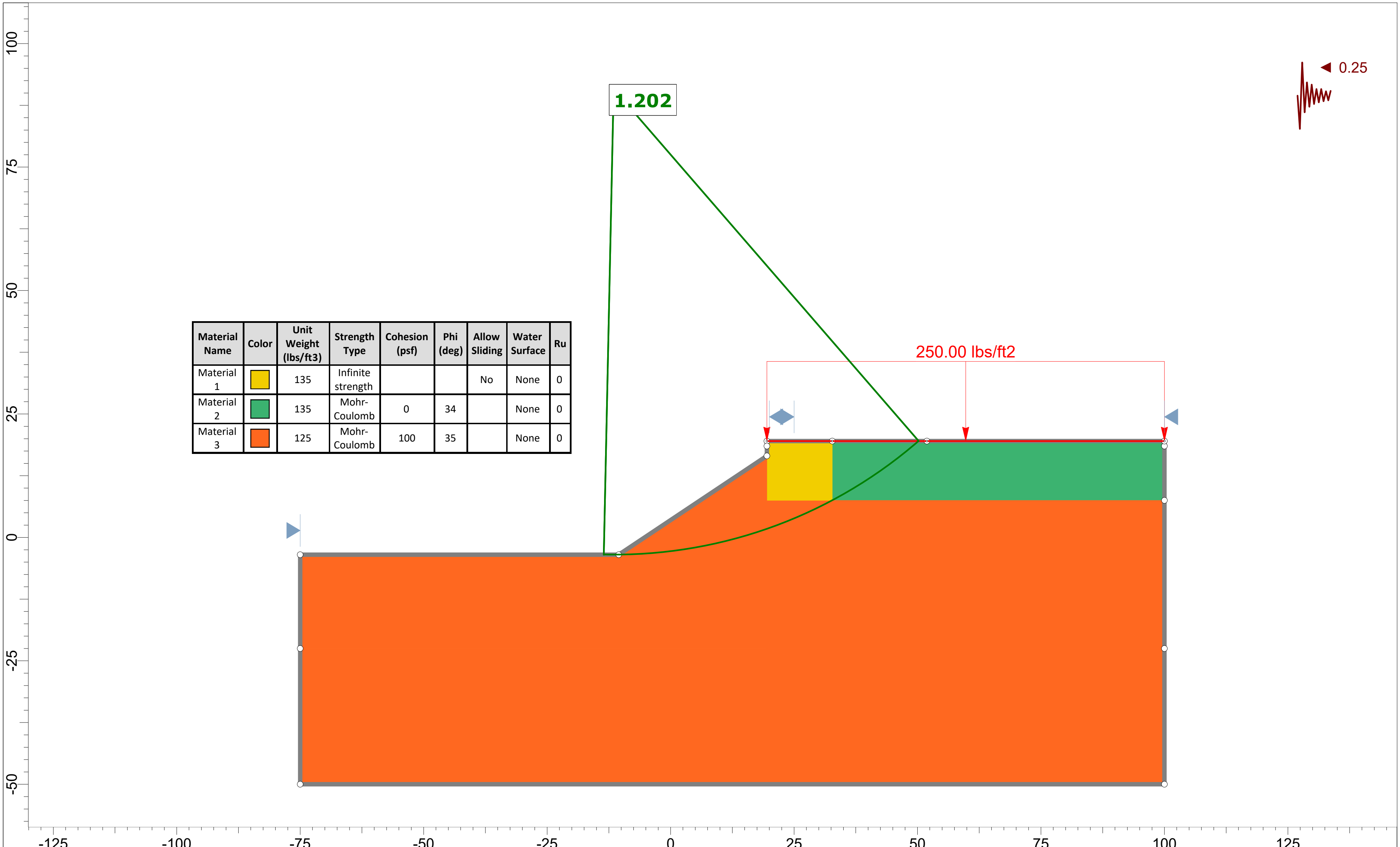


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Allow Sliding	Water Surface	Ru
Material 1		135	Infinite strength			No	None	0
Material 2		135	Mohr-Coulomb	0	34		None	0
Material 3		125	Mohr-Coulomb	100	35		None	0

rocscience

SLIDEINTERPRET 9.019

Project	SLIDE - An Interactive Slope Stability Program
Group	Group 1
Scenario	Master Scenario
Drawn By	
Company	
Date	6/13/2022, 1:58:23 PM
File Name	G-1092 - RW16 Parallel Critical Section Static.slmd



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Allow Sliding	Water Surface	Ru
Material 1	Yellow	135	Infinite strength			No	None	0
Material 2	Green	135	Mohr-Coulomb	0	34		None	0
Material 3	Orange	125	Mohr-Coulomb	100	35		None	0

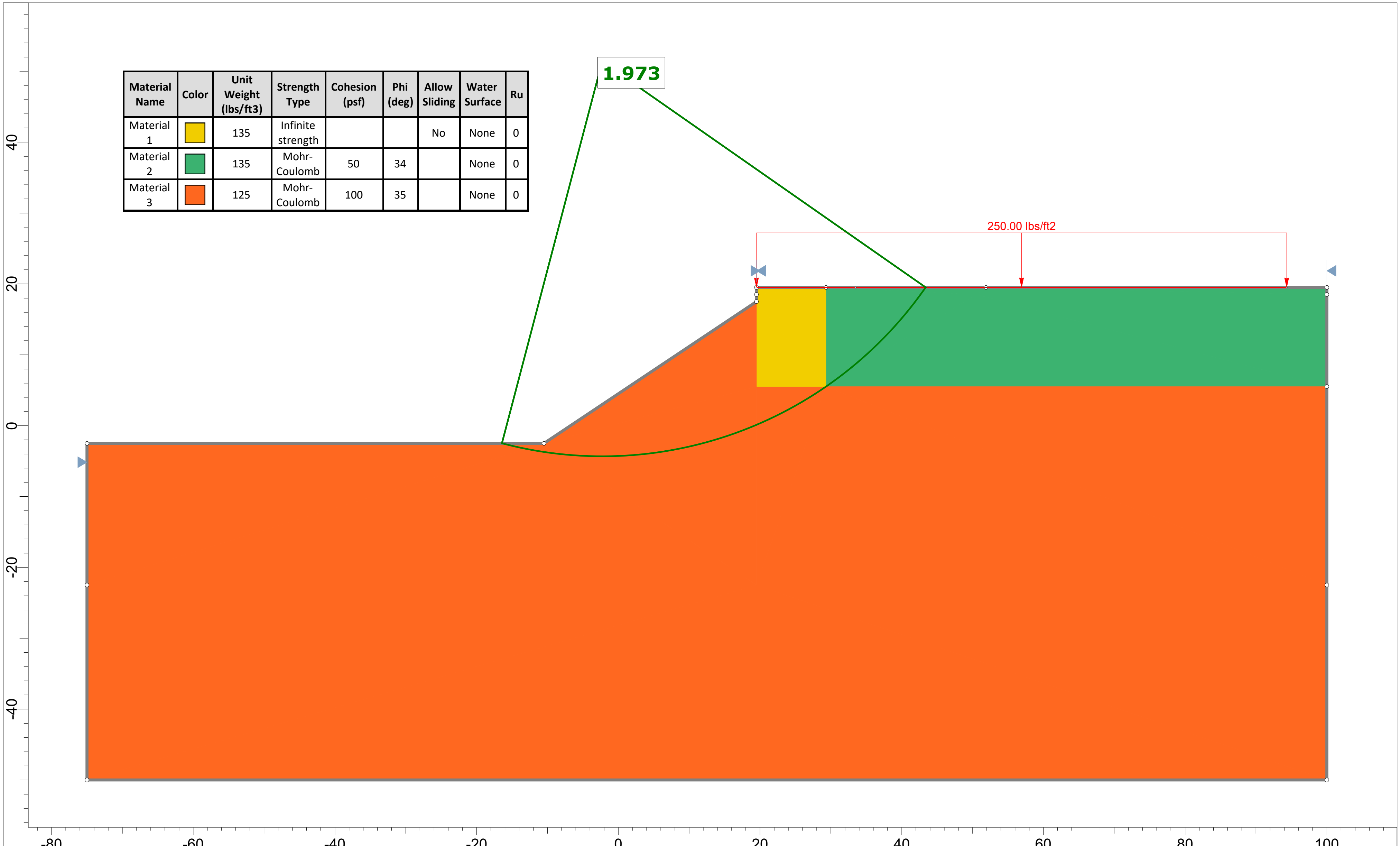
rocscience

SLIDEINTERPRET 9.019

Project	SLIDE - An Interactive Slope Stability Program

Group	Group 1	*Scenario*	Master Scenario
Drawn By		*Company*	
Date	6/13/2022, 1:58:23 PM	*File Name*	G-1092 - RW16 Parallel Critical Section Pseudo-Static.slmd

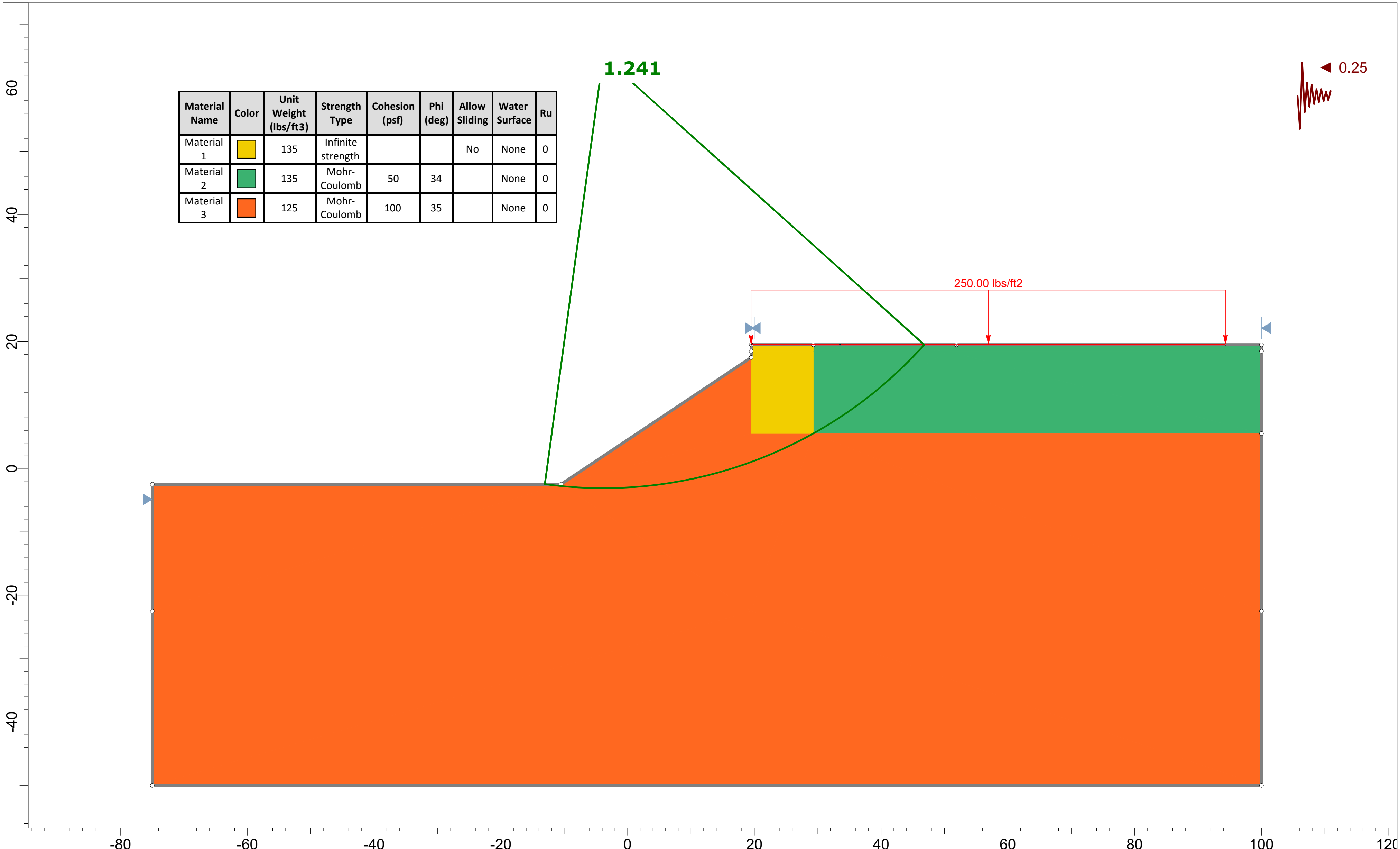
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Allow Sliding	Water Surface	Ru
Material 1		135	Infinite strength			No	None	0
Material 2		135	Mohr-Coulomb	50	34		None	0
Material 3		125	Mohr-Coulomb	100	35		None	0



rocscience

SLIDEINTERPRET 9.019

Project	SLIDE - An Interactive Slope Stability Program		
Group	Group 1	*Scenario*	Master Scenario
Drawn By		*Company*	
Date	6/13/2022, 1:58:23 PM	*File Name*	G-1092 - RW17 Parallel Critical Section Static.slmd



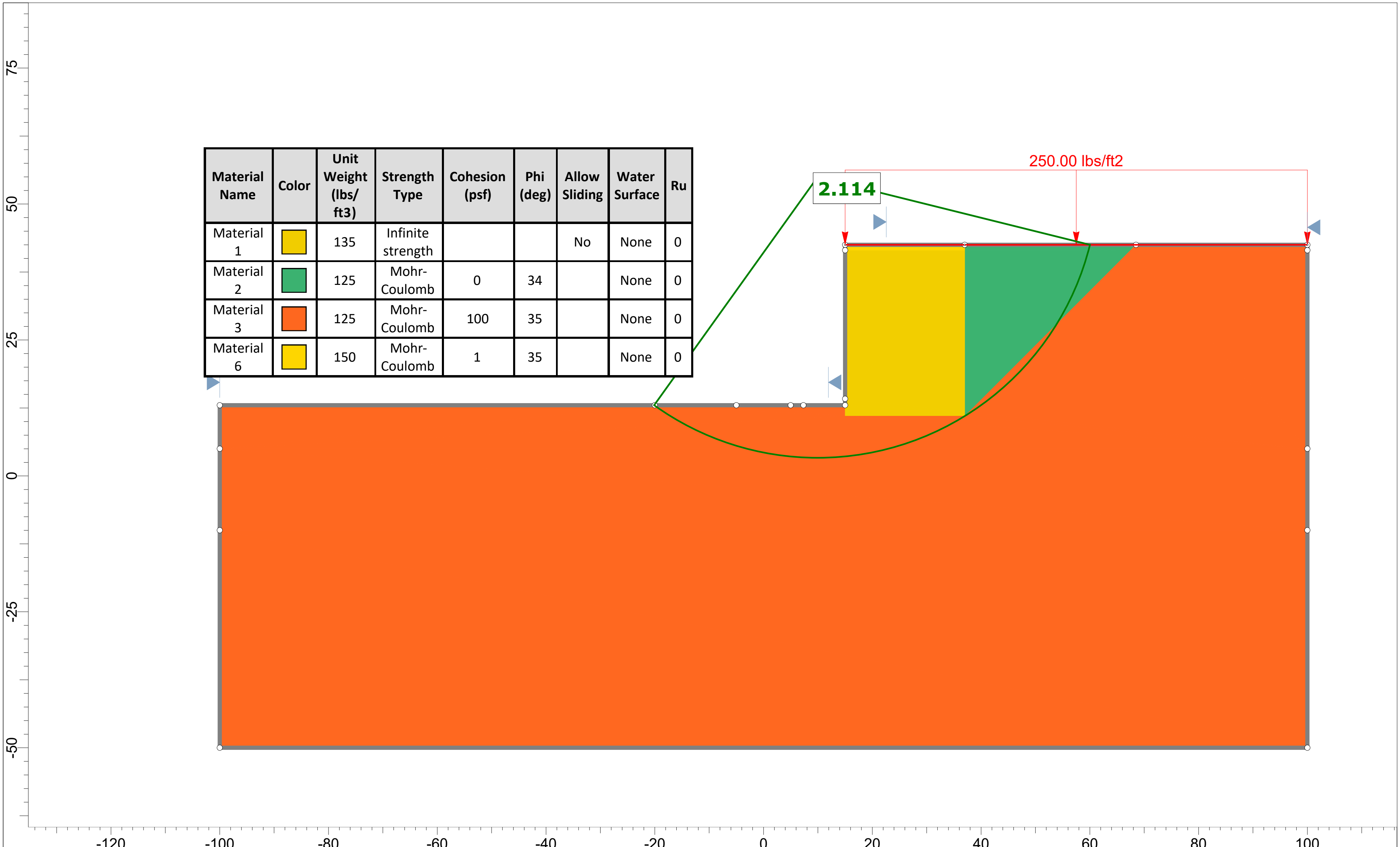
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Allow Sliding	Water Surface	Ru
Material 1		135	Infinite strength			No	None	0
Material 2		135	Mohr-Coulomb	50	34		None	0
Material 3		125	Mohr-Coulomb	100	35		None	0

rocscience

SLIDEINTERPRET 9.019

Project	SLIDE - An Interactive Slope Stability Program
Group Group 1	*Scenario* Master Scenario
Drawn By	*Company*
Date 6/13/2022, 1:58:23 PM	*File Name* G-1092 - RW17 Parallel Critical Section Pseudo-Static.slmd

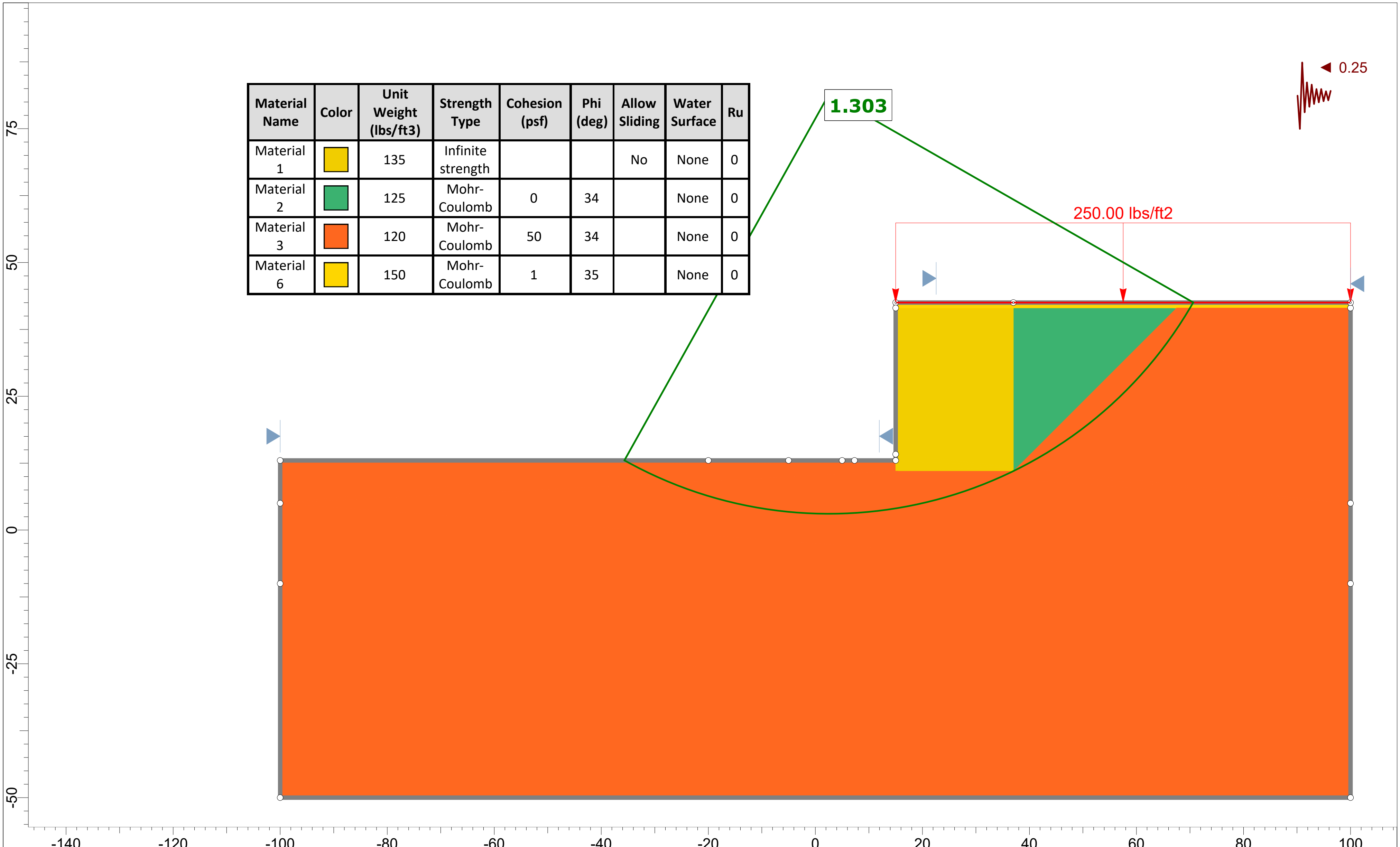
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Allow Sliding	Water Surface	Ru
Material 1		135	Infinite strength			No	None	0
Material 2		125	Mohr-Coulomb	0	34		None	0
Material 3		125	Mohr-Coulomb	100	35		None	0
Material 6		150	Mohr-Coulomb	1	35		None	0



rocscience

SLIDEINTERPRET 9.019

Project	SLIDE - An Interactive Slope Stability Program		
Group	Group 1	*Scenario*	Master Scenario
Drawn By		*Company*	
Date	6/13/2022, 1:58:23 PM	*File Name*	I-1093 - Perpendicular Main Section Static.slmd

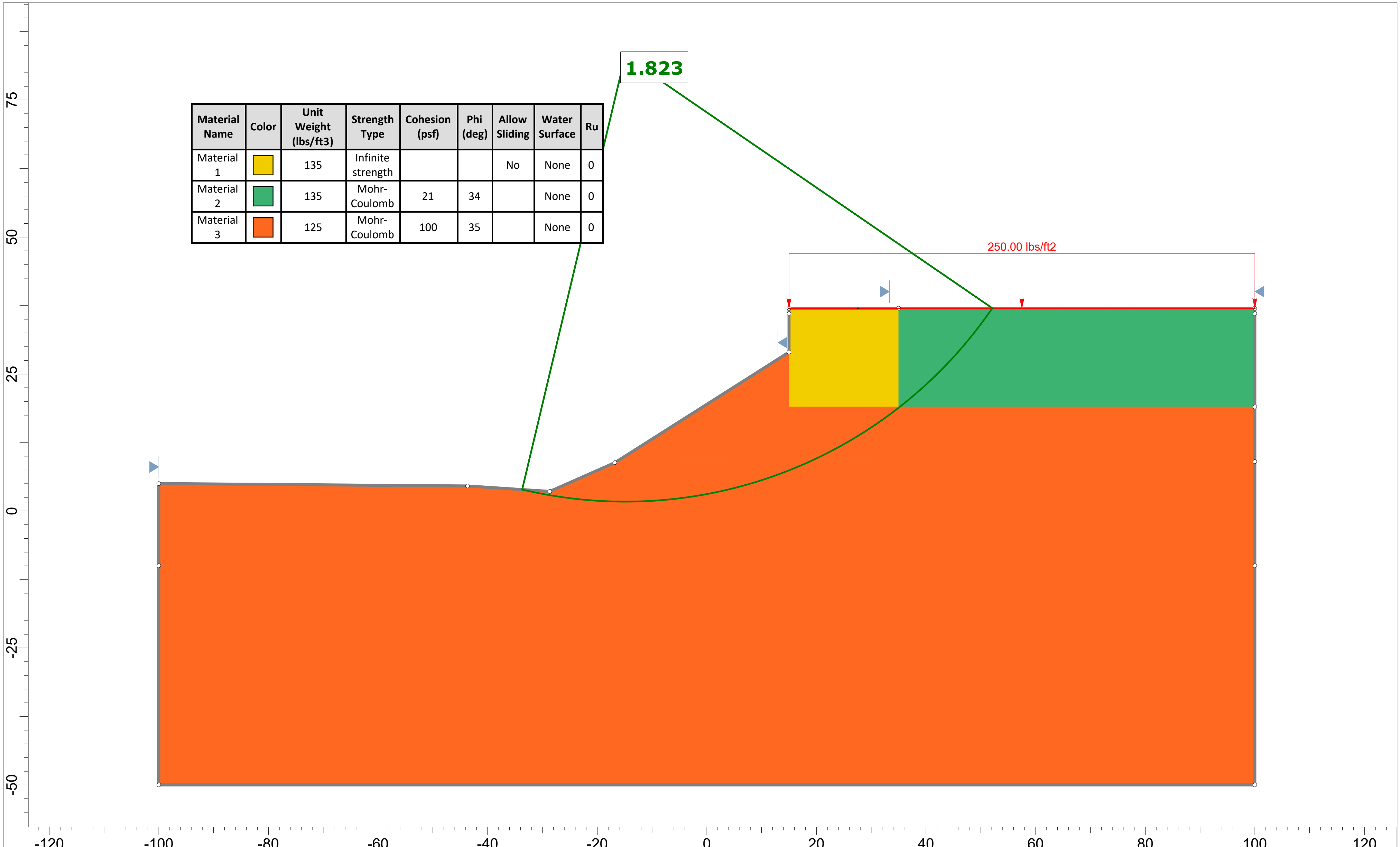


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Allow Sliding	Water Surface	Ru
Material 1		135	Infinite strength			No	None	0
Material 2		125	Mohr-Coulomb	0	34		None	0
Material 3		120	Mohr-Coulomb	50	34		None	0
Material 6		150	Mohr-Coulomb	1	35		None	0

rocscience

SLIDEINTERPRET 9.019

Project	SLIDE - An Interactive Slope Stability Program		
Group	Group 1	*Scenario*	Master Scenario
Drawn By		*Company*	
Date	6/13/2022, 1:58:23 PM	*File Name*	I-1093 - Perpendicular Main Section Pseudo-Static.slmd

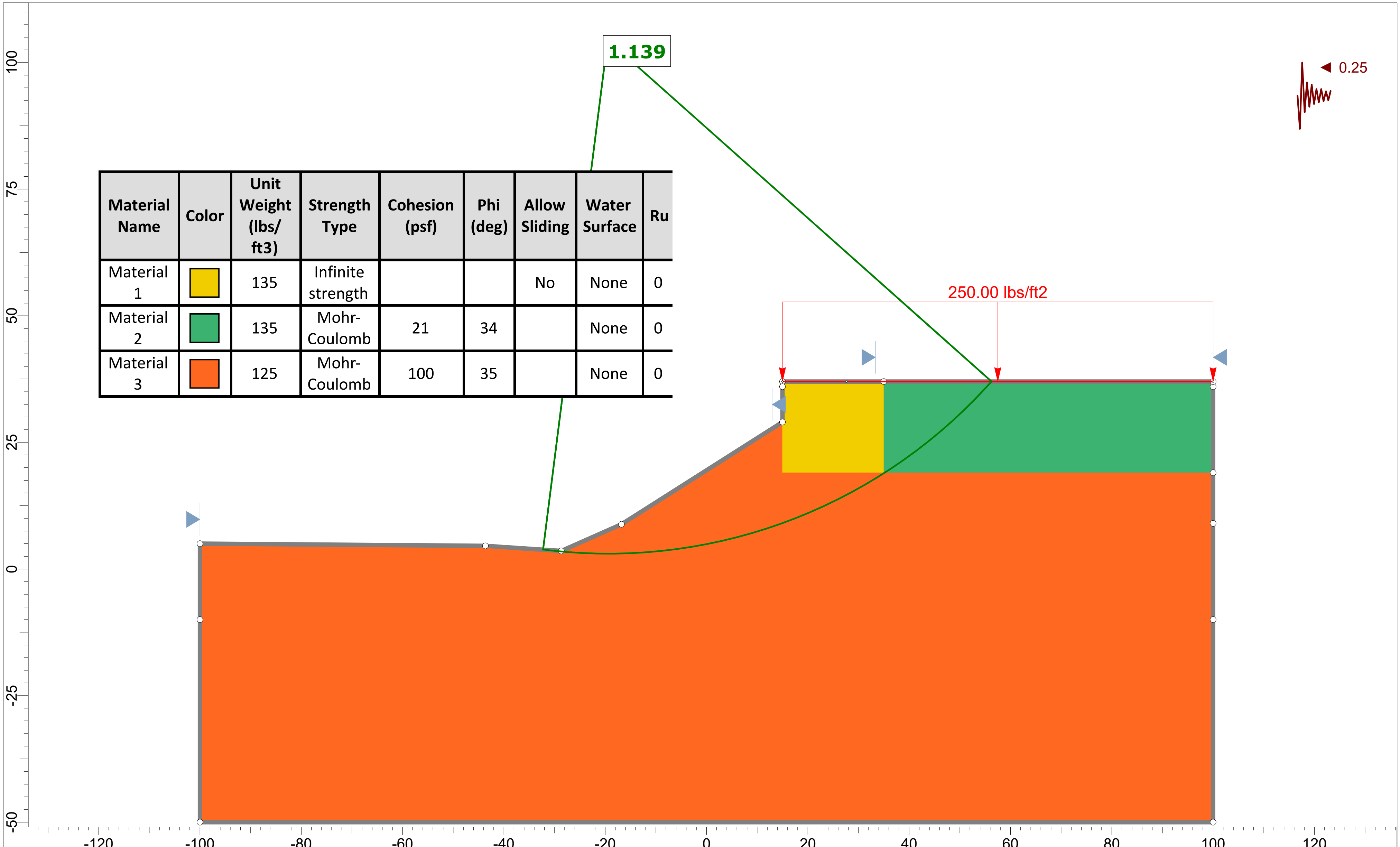


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Allow Sliding	Water Surface	Ru
Material 1		135	Infinite strength			No	None	0
Material 2		135	Mohr-Coulomb	21	34		None	0
Material 3		125	Mohr-Coulomb	100	35		None	0

rocscience

SLIDEINTERPRET 9.019

Project	SLIDE - An Interactive Slope Stability Program		
Group	Group 1	*Scenario*	Master Scenario
Drawn By		*Company*	
Date	6/13/2022, 1:58:23 PM	*File Name*	RW18 Parallel Critical Section Static.slmd

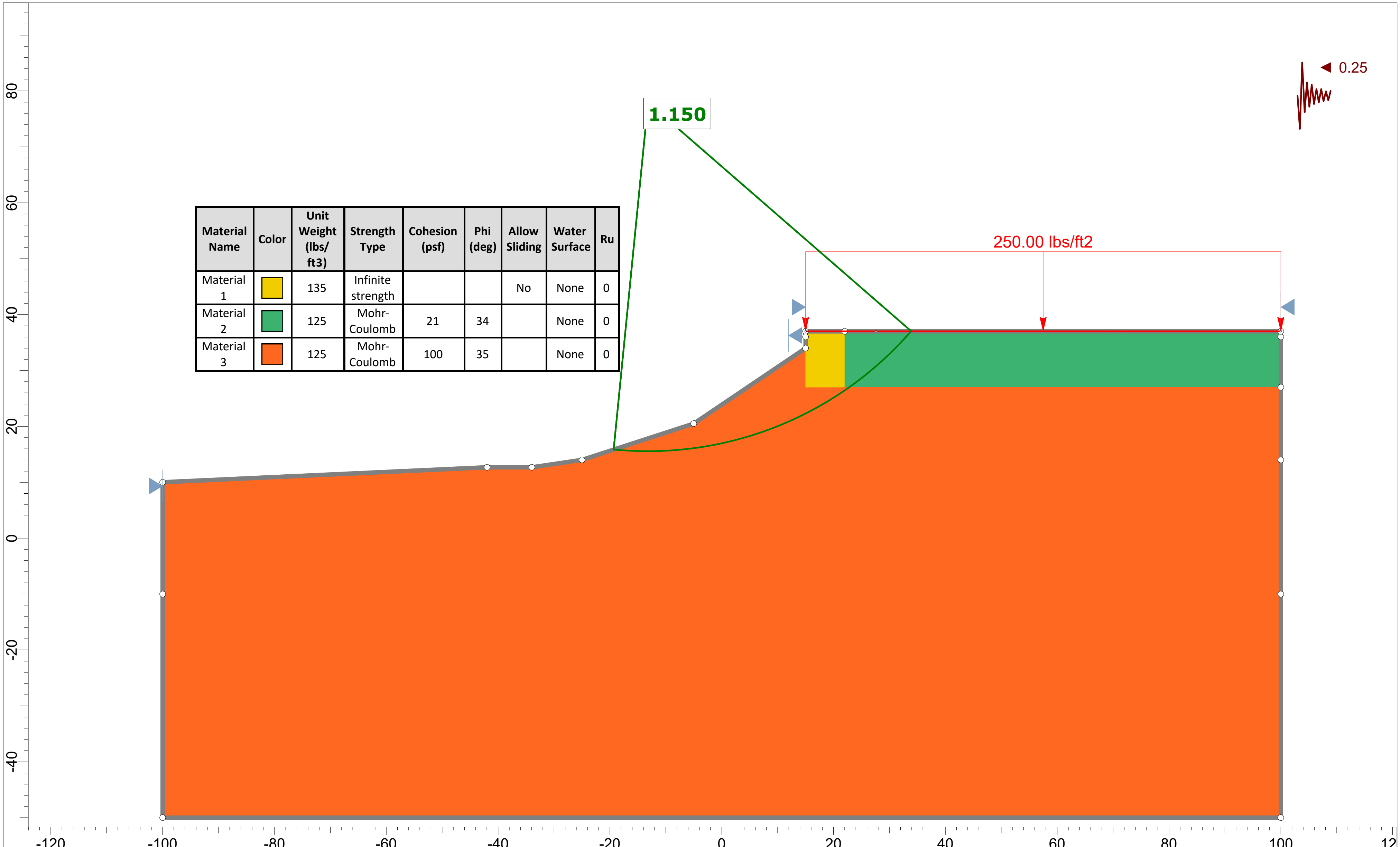


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Allow Sliding	Water Surface	Ru
Material 1	(yellow)	135	Infinite strength			No	None	0
Material 2	(green)	135	Mohr-Coulomb	21	34		None	0
Material 3	(orange)	125	Mohr-Coulomb	100	35		None	0

rocscience

SLIDEINTERPRET 9.019

Project	SLIDE - An Interactive Slope Stability Program		
Group	Group 1	*Scenario*	Master Scenario
Drawn By		*Company*	
Date	6/13/2022, 1:58:23 PM	*File Name*	RW18 Parallel Critical Section Pseudo-Static.slmd

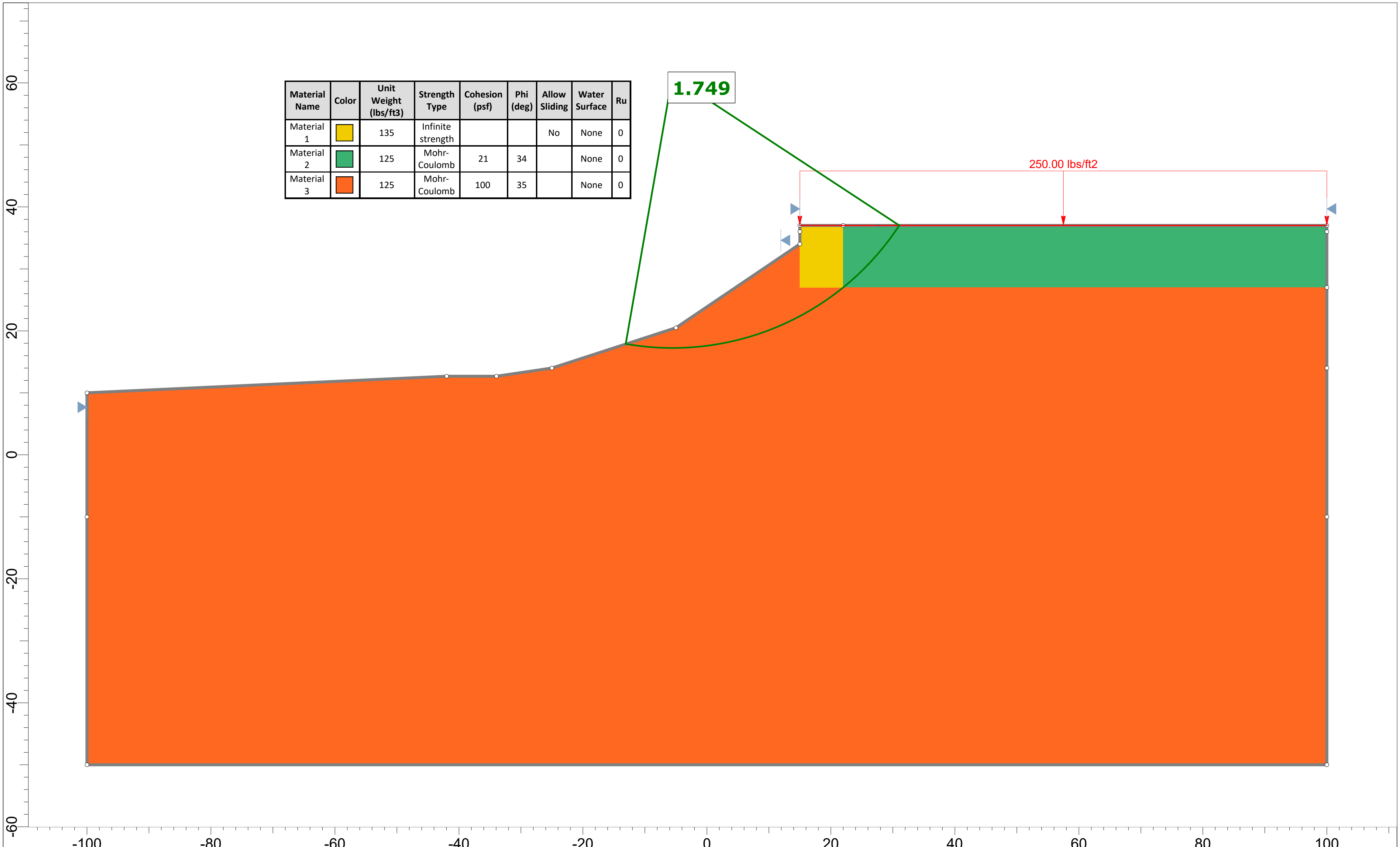


Material Name	Color	Unit Weight (lbs/ ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Allow Sliding	Water Surface	Ru
Material 1		135	Infinite strength			No	None	0
Material 2		125	Mohr-Coulomb	21	34		None	0
Material 3		125	Mohr-Coulomb	100	35		None	0

Project	SLIDE - An Interactive Slope Stability Program		
Group	Group 1	*Scenario*	Master Scenario
Drawn By		*Company*	
Date	6/13/2022, 1:58:23 PM	*File Name*	RW19 Parallel Critical Section Pseudo-Static.slmd

rocscience

SLIDEINTERPRET 9.019



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Allow Sliding	Water Surface	Ru
Material 1		135	Infinite strength			No	None	0
Material 2		125	Mohr-Coulomb	21	34		None	0
Material 3		125	Mohr-Coulomb	100	35		None	0

rocscience

SLIDEINTERPRET 9.019

Project	SLIDE - An Interactive Slope Stability Program		
Group	Group 1	*Scenario*	Master Scenario
Drawn By		*Company*	
Date	6/13/2022, 1:58:23 PM	*File Name*	RW19 Parallel Critical Section Static.slmd

Appendix B
External Stability Results

AASHTO 2017-2020
North Valleys G-1092

MSEW+: Update # 2021.14

PROJECT IDENTIFICATION

Title: North Valleys G-1092
Project Number: RW 16 & 17 Perpendicular
Client: NDOT
Designer: George Helgerson
Station Number:

Description:

Company's information:

Name: NDOT
Street:

,
Telephone #:
Fax #:
E-Mail:

File path and name: \\datsrv1\028GeoTechnical\00 Projects\74107 395 North V.....
.....SEW\MSEW G-1092.BENp

Original date and time of creating this file: Tue Jun 28 13:17:19 2022

PROGRAM MODE: ANALYSIS
of a SIMPLE STRUCTURE
using METAL STRIPS as reinforcing material.

SOIL DATA

REINFORCED SOIL

Unit weight, γ	135.0 lb/ft ³
Design value of internal angle of friction, ϕ	34.0 °

RETAINED SOIL

Unit weight, γ	125.0 lb/ft ³
Design value of internal angle of friction, ϕ	34.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	125.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{equiv.}$	35.0 °
Equivalent cohesion, $c_{equiv.}$	50.0 lb/ft ²

Water table does not affect bearing capacity

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.2827 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Ka (external stability) = 0.2827 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity is controlled by general shear.
Bearing capacity factors (calculated by MSEW): Nc = 24.01 N_γ = 25.00

SEISMICITY (using AASHTO 2017-2020)

Peak ground acceleration coeff., A = PGA = 0.500 and Site Factor, Fpga = 1.076. Maximum ground acceleration coeff., As = 0.538
Design acceleration coefficient in Internal Stability: Kh = Am = 0.218
Design acceleration coefficient in External Stability: Kh_d = 0.218 => Kh = Am = 0.218

Kae (Kh > 0) = 0.4240 Kae (Kh = 0) = 0.2827
Seismic soil-metal strip friction coefficient, F* is 80.0% of its specified static value.

INPUT DATA: Geometry and Surcharge loads (of a SIMPLE STRUCTURE)

Design height, Hd 30.00 [ft] { Embedded depth is E = 2.00 ft, and height above top of finished bottom grade is H = 28.00 ft }
Soil in front of wall is inclined at 27.0°, Hs = 8.00 ft. and bs = 2.00 ft.

Batter, ω	0.0	[deg]
Backslope, β	0.0	[deg]
Backslope rise	0.0	[ft]

Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)

U N I F O R M S U R C H A R G E

Uniformly distributed dead load is 0.0 [lb/ft ²], and live load is 250.0 [lb/ft ²]

ANALYZED REINFORCEMENT LAYOUT:

SCALE:

0 2 4 6 8 10[ft]

AASHTO 2017-2020 – Load and Resisting Factors

EXTERNAL STABILITY

Load factor for vertical earth pressure, EV			Static		Combined Static/Seismic
	Sliding and Eccentricity	$\gamma_{p\text{-}EV}$	1.00	$\gamma_{p\text{-}EQ}$	1.00
	Bearing Capacity	$\gamma_{p\text{-}EV}$	1.35	$\gamma_{p\text{-}EQ}$	1.35

Load factor of active lateral earth pressure, EH $\gamma_{p\text{-}EH}$ 1.50
Load factor of active lateral earth pressure during earthquake (does not multiply P_{AE} and P_{IR}): $(\gamma_{p\text{-}EH})_{EQ}$ 1.50
Load factor for earthquake loads, EQ (multiplies P_{AE} and P_{IR}): $\gamma_{p\text{-}EQ}$ 1.00

Resistance factor for shear resistance along common interfaces			Static	Combined Static/Seismic
	Reinforced Soil and Foundation	ϕ_{τ}	1.00	1.00
	Reinforced Soil and Reinforcement	ϕ_{τ}	1.00	1.00

Resistance factor for bearing capacity of shallow foundation		Static	Combined Static/Seismic
	ϕ_b	0.65	0.65

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 2.27, factored bearing load = 7629 lb/ft².

Foundation Interface: Direct sliding, CDR = 2.081, Eccentricity, e/L = 0.1647, CDR-overturning = 3.04

METAL STRIP				CONNECTION						
#	Elevation [ft]	Length [ft]	Type #	CDR [connection break]	CDR Strength	Metal strip strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.98	21.00	1					2.131	0.1551	---
2	3.44	21.00	1					2.299	0.1323	---
3	5.91	21.00	1					2.496	0.1111	---
4	8.37	21.00	1					2.730	0.0919	---
5	10.83	21.00	1					3.017	0.0744	---
6	13.29	21.00	1					3.375	0.0588	---
7	15.75	21.00	1					3.814	0.0449	---
8	18.21	21.00	1					4.384	0.0329	---
9	20.67	21.00	1					5.155	0.0226	---
10	23.13	21.00	1					6.254	0.0141	---
11	25.59	21.00	1					7.949	0.0075	---
12	28.05	21.00	1					10.904	0.0026	---

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, CDR = 1.35, factored bearing load = 9955 lb/ft².

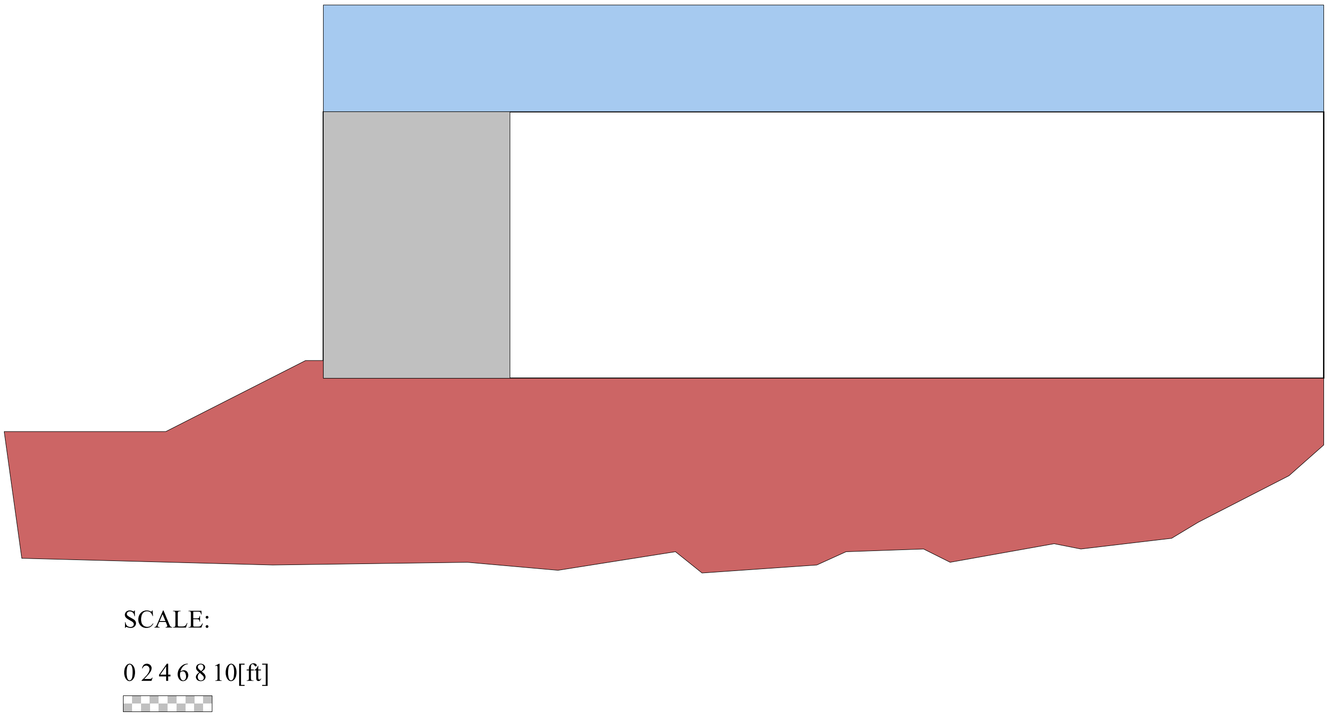
Foundation Interface: Direct sliding, CDR = 1.406, Eccentricity, e/L = 0.2966, Fs-overturning = 1.69

METAL STRIP				CONNECTION						
#	Elevation [ft]	Length [ft]	Type #	CDR [connection break]	CDR Strength	Metal strip strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.98	21.00	1					1.442	0.2791	---
2	3.44	21.00	1					1.562	0.2377	---
3	5.91	21.00	1					1.705	0.1994	---
4	8.37	21.00	1					1.875	0.1646	---
5	10.83	21.00	1					2.087	0.1331	---
6	13.29	21.00	1					2.355	0.1048	---
7	15.75	21.00	1					2.690	0.0799	---
8	18.21	21.00	1					3.138	0.0582	---
9	20.67	21.00	1					3.764	0.0398	---
10	23.13	21.00	1					4.702	0.0247	---
11	25.59	21.00	1					6.262	0.0129	---
12	28.05	21.00	1					9.373	0.0044	---

BEARING CAPACITY for GIVEN LAYOUT – Using AASHTO 2017-2020 method

	STATIC	SEISMIC	UNITS
(Water table does not affect bearing capacity)			
Factored bearing resistance. q-n	17288	13431	[lb/ft ²]
Factored bearing load, σ_V	7628.7	9955	[lb/ft ²]
Eccentricity, e	2.37	4.27	[ft]
Eccentricity, e/L	0.113	0.203	
CDR calculated	2.27	1.35	
Base length	21.00	21.00	[ft]

Unfactored applied bearing pressure = (Unfactored R) / [L - 2 * (Unfactored e)] =
Static: Unfactored R = 90299.94 [lb/ft], L = 21.00, Unfactored e = 2.11 [ft], and Sigma = 5383.53 [lb/ft ²]
Seismic: Unfactored R = 90299.94 [lb/ft], L = 21.00, Unfactored e = 4.54 [ft], and Sigma = 7581.77 [lb/ft ²]



DIRECT SLIDING for GIVEN LAYOUT (for METAL STRIPS reinforcements)

Along reinforced and foundation soils interface: CDR-static = 2.081 and CDR-seismic = 1.406

#	Metal strip Elevation [ft]	Metal strip Length [ft]	CDR Static	CDR Seismic	Metal strip Type #	Product name
1	0.98	21.00	2.131	1.442	1	---
2	3.44	21.00	2.299	1.562	1	---
3	5.91	21.00	2.496	1.705	1	---
4	8.37	21.00	2.730	1.875	1	---
5	10.83	21.00	3.017	2.087	1	---
6	13.29	21.00	3.375	2.355	1	---
7	15.75	21.00	3.814	2.690	1	---
8	18.21	21.00	4.384	3.138	1	---
9	20.67	21.00	5.155	3.764	1	---
10	23.13	21.00	6.254	4.702	1	---
11	25.59	21.00	7.949	6.262	1	---
12	28.05	21.00	10.904	9.373	1	---

ECCENTRICITY for GIVEN LAYOUT (for Simplified Method)

At interface with foundation: e/L static = 0.1647, e/L seismic = 0.2966; Overturning: CDR-static = 3.04, CDR-seismic = 1.69

#	Metal strip Elevation [ft]	Metal strip Length [ft]	e / L Static	e / L Seismic	Metal strip Type #	Product name
1	0.98	21.00	0.1551	0.2791	1	---
2	3.44	21.00	0.1323	0.2377	1	---
3	5.91	21.00	0.1111	0.1994	1	---
4	8.37	21.00	0.0919	0.1646	1	---
5	10.83	21.00	0.0744	0.1331	1	---
6	13.29	21.00	0.0588	0.1048	1	---
7	15.75	21.00	0.0449	0.0799	1	---
8	18.21	21.00	0.0329	0.0582	1	---
9	20.67	21.00	0.0226	0.0398	1	---
10	23.13	21.00	0.0141	0.0247	1	---
11	25.59	21.00	0.0075	0.0129	1	---
12	28.05	21.00	0.0026	0.0044	1	---

AASHTO 2017-2020
North Valleys G-1092

MSEW+: Update # 2021.14

PROJECT IDENTIFICATION

Title:	North Valleys G-1092
Project Number:	RW 16 Parallel
Client:	NDOT
Designer:	George Helgerson
Station Number:	

Description:

Company's information:

Name: NDOT
Street:

,
Telephone #:
Fax #:
E-Mail:

File path and name: \\datsrv1\028GeoTechnical\00 Projects\74107 395 North V.....
.....2 RW16 Parallel.BENp

Original date and time of creating this file: Tue Jun 28 13:17:19 2022

PROGRAM MODE: ANALYSIS
of a SIMPLE STRUCTURE
using METAL STRIPS as reinforcing material.

SOIL DATA

REINFORCED SOIL

Unit weight, γ	135.0 lb/ft ³
Design value of internal angle of friction, ϕ	34.0 °

RETAINED SOIL

Unit weight, γ	125.0 lb/ft ³
Design value of internal angle of friction, ϕ	34.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	125.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{equiv.}$	35.0 °
Equivalent cohesion, $c_{equiv.}$	100.0 lb/ft ²

Water table does not affect bearing capacity

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.2827 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Ka (external stability) = 0.2827 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity is controlled by general shear.
Bearing capacity factors (calculated by MSEW): Nc = 7.43 N γ= 7.74

SEISMICITY (using AASHTO 2017-2020)

Peak ground acceleration coeff., A = PGA = 0.500 and Site Factor, Fpga = 1.076. Maximum ground acceleration coeff., As = 0.538
Design acceleration coefficient in Internal Stability: Kh = Am = 0.218
Design acceleration coefficient in External Stability: Kh_d = 0.218 => Kh = Am = 0.218

Kae (Kh > 0) = 0.4240 Kae (Kh = 0) = 0.2827
Seismic soil-metal strip friction coefficient, F* is 80.0% of its specified static value.

INPUT DATA: Geometry and Surcharge loads (of a SIMPLE STRUCTURE)

Design height, Hd 12.00 [ft] { Embedded depth is E = 5.00 ft, and height above top of finished bottom grade is H = 7.00 ft }

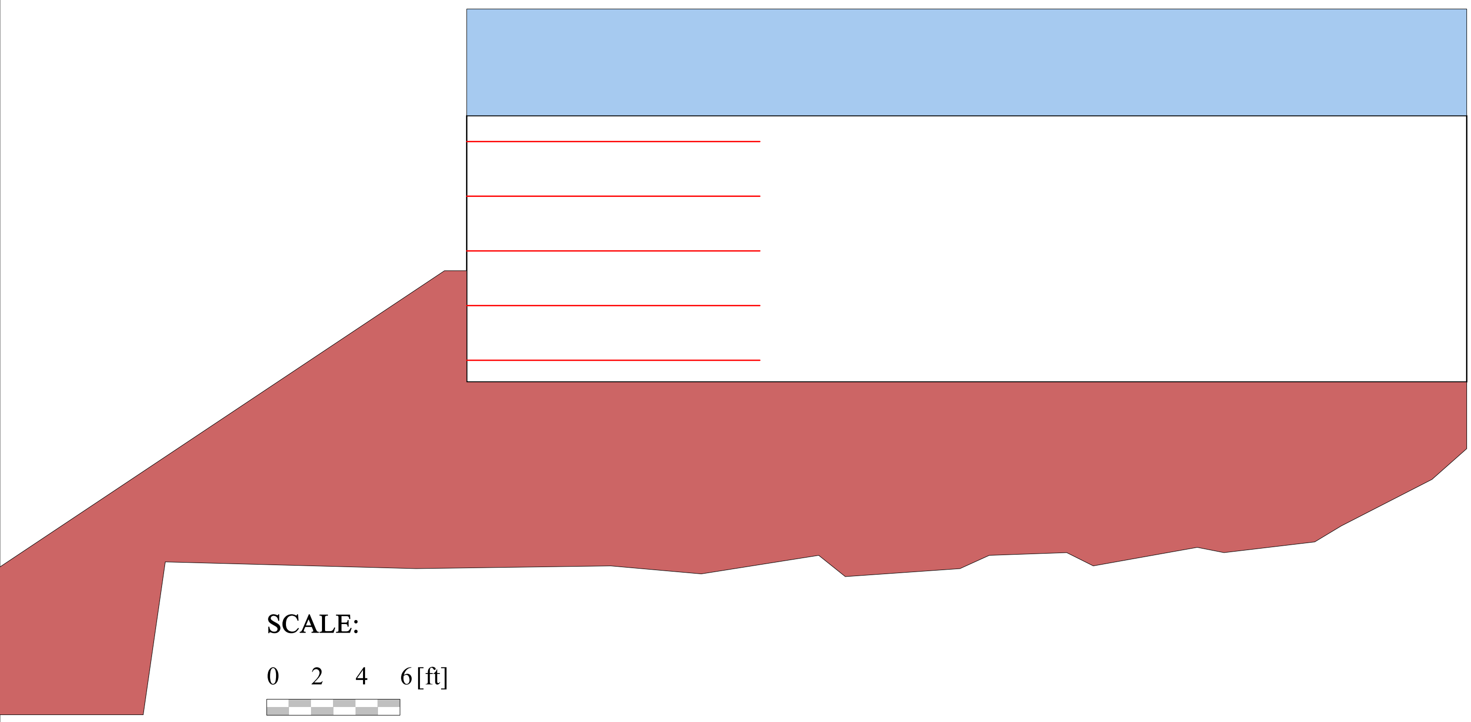
Soil in front of wall is inclined at 33.7°, Hs = 20.00 ft. and bs = 1.00 ft.

Batter, ω	0.0	[deg]	
Backslope, β	0.0	[deg]	
Backslope rise	0.0	[ft]	Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)

U N I F O R M S U R C H A R G E

Uniformly distributed dead load is 0.0 [lb/ft ²], and live load is 250.0 [lb/ft ²]

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 [ft]

AASHTO 2017-2020 – Load and Resisting Factors

EXTERNAL STABILITY

Load factor for vertical earth pressure, EV		Static	Combined Static/Seismic	
Sliding and Eccentricity	$\gamma_{p\text{-}EV}$	1.00	$\gamma_{p\text{-}EQ}$	1.00
Bearing Capacity	$\gamma_{p\text{-}EV}$	1.35	$\gamma_{p\text{-}EQ}$	1.35

Load factor of active lateral earth pressure, EH	$\gamma_{p\text{-}EH}$	1.50
Load factor of active lateral earth pressure during earthquake (does not multiply P_{AE} and P_{IR}):	$(\gamma_{p\text{-}EH})_{EQ}$	1.50
Load factor for earthquake loads, EQ (multiplies P_{AE} and P_{IR}):	$\gamma_{p\text{-}EQ}$	1.00

Resistance factor for shear resistance along common interfaces		Static	Combined Static/Seismic
Reinforced Soil and Foundation	ϕ_{τ}	1.00	1.00
Reinforced Soil and Reinforcement	ϕ_{τ}	1.00	1.00

Resistance factor for bearing capacity of shallow foundation		Static	Combined Static/Seismic
	ϕ_b	0.65	0.65

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 1.43, factored bearing load = 2935 lb/ft².

Foundation Interface: Direct sliding, CDR = 2.721, Eccentricity, e/L = 0.0856, CDR-overturning = 5.84

METAL STRIP				CONNECTION						
#	Elevation [ft]	Length [ft]	Type #	CDR [connection break]	CDR Strength	Metal strip strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.98	13.20	1					2.891	0.0746	---
2	3.44	13.20	1					3.429	0.0500	---
3	5.91	13.20	1					4.216	0.0299	---
4	8.37	13.20	1					5.466	0.0145	---
5	10.83	13.20	1					7.770	0.0036	---

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, CDR = 1.19, factored bearing load = 3229 lb/ft².

Foundation Interface: Direct sliding, CDR = 1.945, Eccentricity, e/L = 0.1516, Fs-overturning = 3.30

METAL STRIP				CONNECTION						
#	Elevation [ft]	Length [ft]	Type #	CDR [connection break]	CDR Strength	Metal strip strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.98	13.20	1					2.076	0.1318	---
2	3.44	13.20	1					2.424	0.0879	---
3	5.91	13.20	1					2.916	0.0522	---
4	8.37	13.20	1					3.653	0.0250	---
5	10.83	13.20	1					4.891	0.0061	---

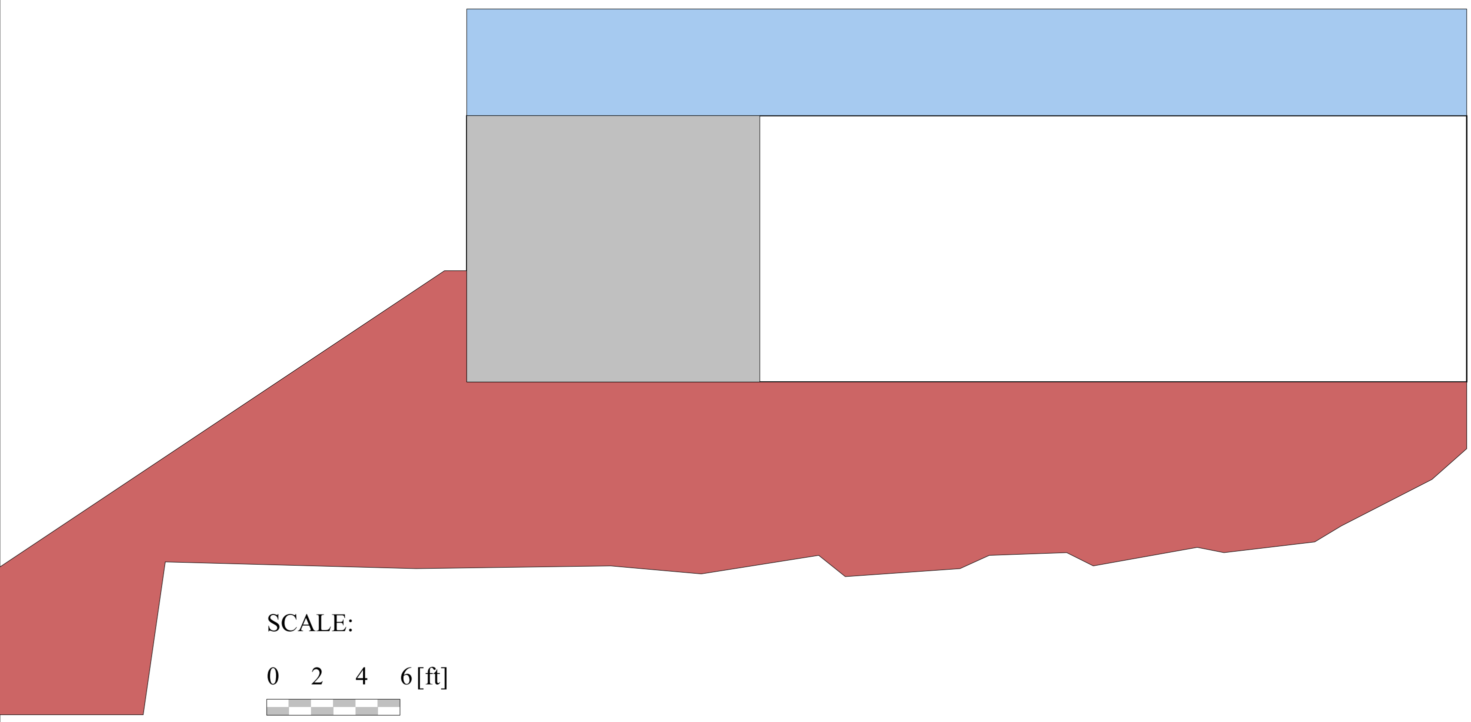
BEARING CAPACITY for GIVEN LAYOUT – Using AASHTO 2017-2020 method

	STATIC	SEISMIC	UNITS
(Water table does not affect bearing capacity)			
Factored bearing resistance. q-n	4195	3856	[lb/ft ²]
Factored bearing load, σ_V	2934.8	3229	[lb/ft ²]
Eccentricity, e	0.70	1.24	[ft]
Eccentricity, e/L	0.053	0.094	
CDR calculated	1.43	1.19	
Base length	13.20	13.20	[ft]

Unfactored applied bearing pressure = (Unfactored R) / [L - 2 * (Unfactored e)] =

Static: Unfactored R = 24683.98 [lb/ft], L = 13.20, Unfactored e = 0.62 [ft], and Sigma = 2063.36 [lb/ft ²]

Seismic: Unfactored R = 24683.98 [lb/ft], L = 13.20, Unfactored e = 1.27 [ft], and Sigma = 2315.68 [lb/ft ²]



DIRECT SLIDING for GIVEN LAYOUT (for METAL STRIPS reinforcements)

Along reinforced and foundation soils interface: CDR-static = 2.721 and CDR-seismic = 1.945

#	Metal strip Elevation [ft]	Metal strip Length [ft]	CDR Static	CDR Seismic	Metal strip Type #	Product name
1	0.98	13.20	2.891	2.076	1	---
2	3.44	13.20	3.429	2.424	1	---
3	5.91	13.20	4.216	2.916	1	---
4	8.37	13.20	5.466	3.653	1	---
5	10.83	13.20	7.770	4.891	1	---

ECCENTRICITY for GIVEN LAYOUT (for Simplified Method)

At interface with foundation: e/L static = 0.0856, e/L seismic = 0.1516; Overturning: CDR-static = 5.84, CDR-seismic = 3.30

#	Metal strip Elevation [ft]	Metal strip Length [ft]	e / L Static	e / L Seismic	Metal strip Type #	Product name
1	0.98	13.20	0.0746	0.1318	1	---
2	3.44	13.20	0.0500	0.0879	1	---
3	5.91	13.20	0.0299	0.0522	1	---
4	8.37	13.20	0.0145	0.0250	1	---
5	10.83	13.20	0.0036	0.0061	1	---

AASHTO 2017-2020
North Valleys G-1092

MSEW+: Update # 2021.14

PROJECT IDENTIFICATION

Title:	North Valleys G-1092
Project Number:	RW 17 Parallel
Client:	NDOT
Designer:	George Helgerson
Station Number:	

Description:

Company's information:

Name: NDOT
Street:

,
Telephone #:
Fax #:
E-Mail:

File path and name: \\datsrv1\028GeoTechnical\00 Projects\74107 395 North V.....
.....SEW G-1092 RW17.BENp

Original date and time of creating this file: Tue Jun 28 13:17:19 2022

PROGRAM MODE: ANALYSIS
of a SIMPLE STRUCTURE
using METAL STRIPS as reinforcing material.

SOIL DATA

REINFORCED SOIL

Unit weight, γ	135.0 lb/ft³
Design value of internal angle of friction, ϕ	34.0 °

RETAINED SOIL

Unit weight, γ	125.0 lb/ft³
Design value of internal angle of friction, ϕ	34.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	125.0 lb/ft³
Equivalent internal angle of friction, $\phi_{equiv.}$	35.0 °
Equivalent cohesion, $c_{equiv.}$	100.0 lb/ft²

Water table does not affect bearing capacity

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.2827 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Ka (external stability) = 0.2827 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity is controlled by general shear.
Bearing capacity factors (calculated by MSEW): Nc = 11.14 N γ= 11.60

SEISMICITY (using AASHTO 2017-2020)

Peak ground acceleration coeff., A = PGA = 0.500 and Site Factor, Fpga = 1.076. Maximum ground acceleration coeff., As = 0.538
Design acceleration coefficient in Internal Stability: Kh = Am = 0.218
Design acceleration coefficient in External Stability: Kh_d = 0.218 => Kh = Am = 0.218

Kae (Kh > 0) = 0.4240 Kae (Kh = 0) = 0.2827
Seismic soil-metal strip friction coefficient, F* is 80.0% of its specified static value.

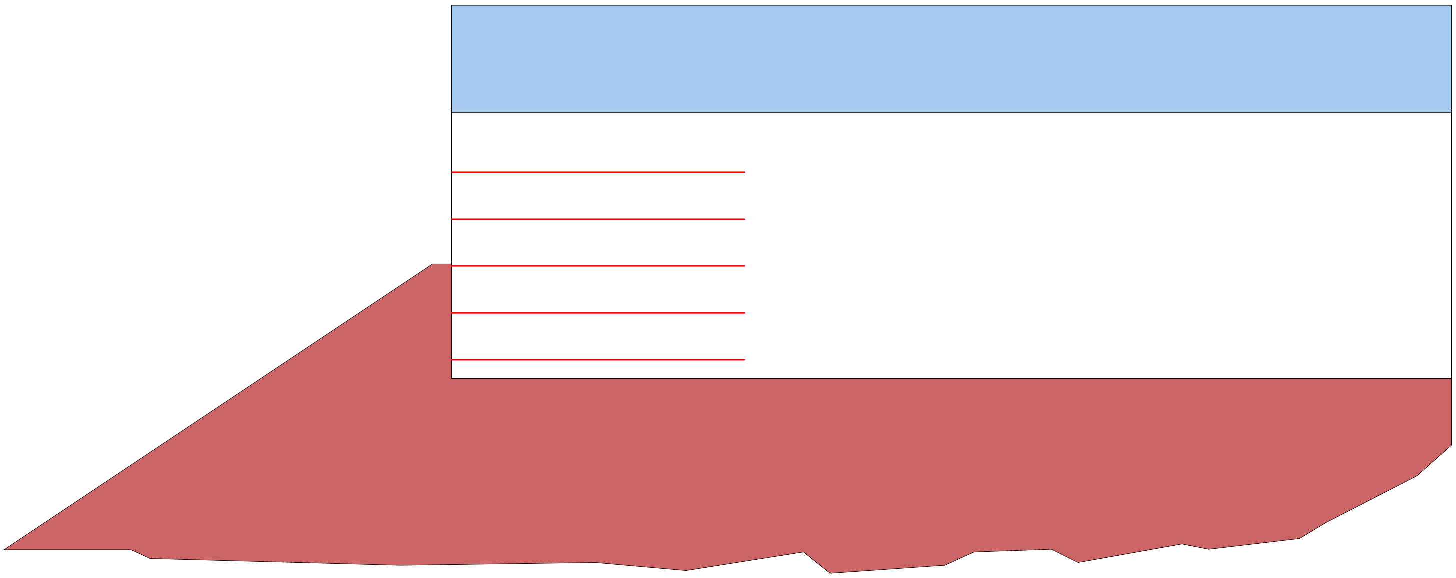
INPUT DATA: Geometry and Surcharge loads (of a SIMPLE STRUCTURE)

Design height, Hd 14.00 [ft] { Embedded depth is E = 6.00 ft, and height above top of finished bottom grade is H = 8.00 ft }
Soil in front of wall is inclined at 33.7°, Hs = 15.00 ft. and bs = 1.00 ft.

Batter, ω	0.0	[deg]	
Backslope, β	0.0	[deg]	
Backslope rise	0.0	[ft]	Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)

UNIFORM SURCHARGE
Uniformly distributed dead load is 0.0 [lb/ft ²], and live load is 250.0 [lb/ft ²]

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 [ft]

AASHTO 2017-2020 – Load and Resisting Factors

EXTERNAL STABILITY

			Static		Combined Static/Seismic
Load factor for vertical earth pressure, EV					
	Sliding and Eccentricity	$\gamma_{p\text{-}EV}$	1.00	$\gamma_{p\text{-}EQ}$	1.00
	Bearing Capacity	$\gamma_{p\text{-}EV}$	1.35	$\gamma_{p\text{-}EQ}$	1.35

Load factor of active lateral earth pressure, EH $\gamma_{p\text{-}EH}$ 1.50

Load factor of active lateral earth pressure during earthquake (does not multiply P_{AE} and P_{IR}): $(\gamma_{p\text{-}EH})_{EQ}$ 1.50

Load factor for earthquake loads, EQ (multiplies P_{AE} and P_{IR}): $\gamma_{p\text{-}EQ}$ 1.00

			Static	Combined Static/Seismic
Resistance factor for shear resistance along common interfaces				
	Reinforced Soil and Foundation	ϕ_τ	1.00	1.00
	Reinforced Soil and Reinforcement	ϕ_τ	1.00	1.00

		Static	Combined Static/Seismic
Resistance factor for bearing capacity of shallow foundation			
	ϕ_b	0.65	0.65

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 2.17, factored bearing load = 3331 lb/ft².

Foundation Interface: Direct sliding, CDR = 2.834, Eccentricity, e/L = 0.0811, CDR-overturning = 6.16

#	METAL STRIP Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection break]	CDR Strength	Metal strip strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.98	15.40	1					2.991	0.0719	---
2	3.44	15.40	1					3.475	0.0512	---
3	5.91	15.40	1					4.147	0.0337	---
4	8.37	15.40	1					5.138	0.0196	---
5	10.83	15.40	1					6.751	0.0089	---

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, CDR = 1.82, factored bearing load = 3655 lb/ft².

Foundation Interface: Direct sliding, CDR = 2.002, Eccentricity, e/L = 0.1441, Fs-overturning = 3.47

#	METAL STRIP Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection break]	CDR Strength	Metal strip strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.98	15.40	1					2.124	0.1276	---
2	3.44	15.40	1					2.510	0.0904	---
3	5.91	15.40	1					3.069	0.0591	---
4	8.37	15.40	1					3.943	0.0341	---
5	10.83	15.40	1					5.515	0.0153	---

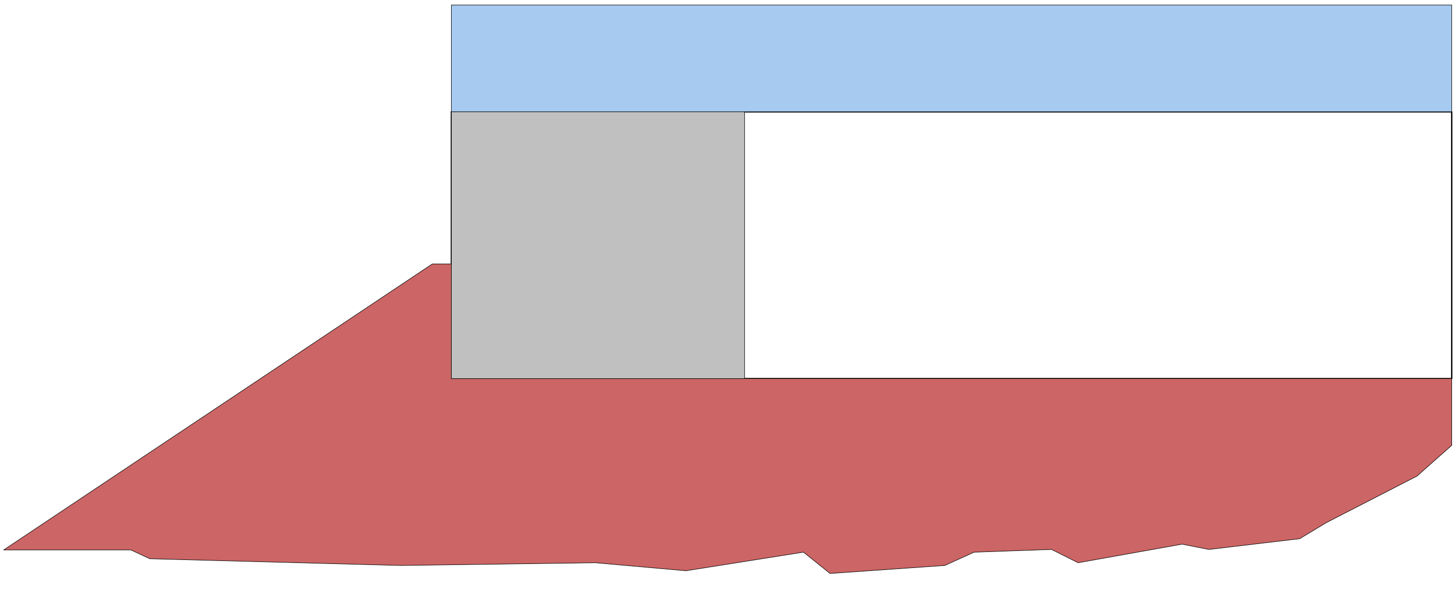
BEARING CAPACITY for GIVEN LAYOUT – Using AASHTO 2017-2020 method

	STATIC	SEISMIC	UNITS
(Water table does not affect bearing capacity)			
Factored bearing resistance. q-n	7235	6657	[lb/ft ²]
Factored bearing load, σ_V	3330.7	3655	[lb/ft ²]
Eccentricity, e	0.79	1.40	[ft]
Eccentricity, e/L	0.051	0.091	
CDR calculated	2.17	1.82	
Base length	15.40	15.40	[ft]

Unfactored applied bearing pressure = (Unfactored R) / [L - 2 * (Unfactored e)] =

Static: Unfactored R = 32955.98 [lb/ft], L = 15.40, Unfactored e = 0.70 [ft], and Sigma = 2354.20 [lb/ft ²]

Seismic: Unfactored R = 32955.98 [lb/ft], L = 15.40, Unfactored e = 1.45 [ft], and Sigma = 2637.51 [lb/ft ²]



SCALE:

0 2 4 6 [ft]

DIRECT SLIDING for GIVEN LAYOUT (for METAL STRIPS reinforcements)

Along reinforced and foundation soils interface: CDR-static = 2.834 and CDR-seismic = 2.002

#	Metal strip Elevation [ft]	Metal strip Length [ft]	CDR Static	CDR Seismic	Metal strip Type #	Product name
1	0.98	15.40	2.991	2.124	1	---
2	3.44	15.40	3.475	2.510	1	---
3	5.91	15.40	4.147	3.069	1	---
4	8.37	15.40	5.138	3.943	1	---
5	10.83	15.40	6.751	5.515	1	---

ECCENTRICITY for GIVEN LAYOUT (for Simplified Method)

At interface with foundation: e/L static = 0.0811, e/L seismic = 0.1441; Overturning: CDR-static = 6.16, CDR-seismic = 3.47

#	Metal strip Elevation [ft]	Metal strip Length [ft]	e / L Static	e / L Seismic	Metal strip Type #	Product name
1	0.98	15.40	0.0719	0.1276	1	---
2	3.44	15.40	0.0512	0.0904	1	---
3	5.91	15.40	0.0337	0.0591	1	---
4	8.37	15.40	0.0196	0.0341	1	---
5	10.83	15.40	0.0089	0.0153	1	---

AASHTO 2017-2020
North Valleys I-1093

MSEW+: Update # 2021.14

PROJECT IDENTIFICATION

Title: North Valleys I-1093
Project Number: RW-19 Perpendicular
Client: NDOT
Designer: George Helgerson
Station Number:

Description:

Company's information:

Name: NDOT
Street:

,
Telephone #:
Fax #:
E-Mail:

File path and name: \\datsrv1\028GeoTechnical\00 Projects\74107 395 North V.....
.....SEW\MSEW I-1093.BENp

Original date and time of creating this file: Tue Jun 28 13:17:19 2022

PROGRAM MODE: ANALYSIS
of a SIMPLE STRUCTURE
using METAL STRIPS as reinforcing material.

SOIL DATA

REINFORCED SOIL

Unit weight, γ	135.0 lb/ft ³
Design value of internal angle of friction, ϕ	34.0 °

RETAINED SOIL

Unit weight, γ	125.0 lb/ft ³
Design value of internal angle of friction, ϕ	34.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	125.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{equiv.}$	34.0 °
Equivalent cohesion, $c_{equiv.}$	50.0 lb/ft ²

Water table does not affect bearing capacity

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.2827 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Ka (external stability) = 0.2827 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity is controlled by general shear.
Bearing capacity factors (calculated by MSEW): Nc = 21.35 N γ= 20.79

SEISMICITY (using AASHTO 2017-2020)

Peak ground acceleration coeff., A = PGA = 0.500 and Site Factor, Fpga = 1.076. Maximum ground acceleration coeff., As = 0.538
Design acceleration coefficient in Internal Stability: Kh = Am = 0.218
Design acceleration coefficient in External Stability: Kh_d = 0.218 => Kh = Am = 0.218

Kae (Kh > 0) = 0.4240 Kae (Kh = 0) = 0.2827
Seismic soil-metal strip friction coefficient, F* is 80.0% of its specified static value.

INPUT DATA: Geometry and Surcharge loads (of a SIMPLE STRUCTURE)

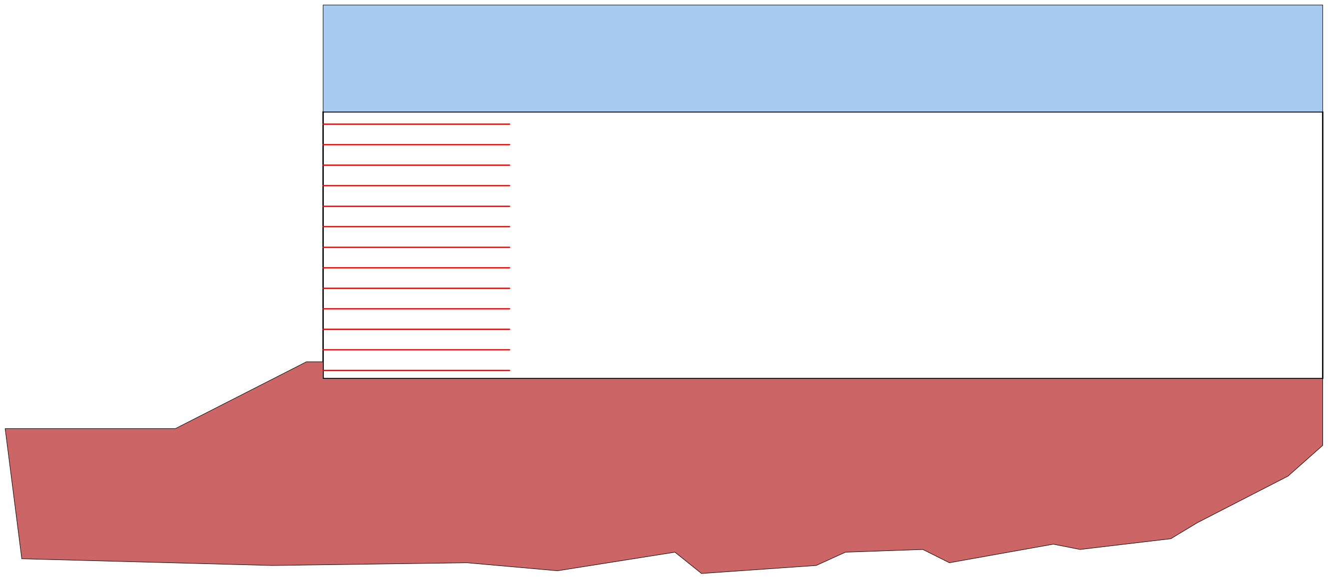
Design height, Hd 32.00 [ft] { Embedded depth is E = 2.00 ft, and height above top of finished bottom grade is H = 30.00 ft }
Soil in front of wall is inclined at 27.0°, Hs = 8.00 ft. and bs = 2.00 ft.

Batter, ω	0.0	[deg]	
Backslope, β	0.0	[deg]	
Backslope rise	0.0	[ft]	Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)

U N I F O R M   S U R C H A R G E

Uniformly distributed dead load is 0.0 [lb/ft ²], and live load is 250.0 [lb/ft ²]

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 5 10 15 20 25 30 [ft]

AASHTO 2017-2020 – Load and Resisting Factors

EXTERNAL STABILITY

Load factor for vertical earth pressure, EV			Static		Combined Static/Seismic
	Sliding and Eccentricity	$\gamma_{p\text{-}EV}$	1.00	$\gamma_{p\text{-}EQ}$	1.00
	Bearing Capacity	$\gamma_{p\text{-}EV}$	1.35	$\gamma_{p\text{-}EQ}$	1.35

Load factor of active lateral earth pressure, EH	$\gamma_{p\text{-}EH}$	1.50
Load factor of active lateral earth pressure during earthquake (does not multiply P_{AE} and P_{IR}):	$(\gamma_{p\text{-}EH})_{EQ}$	1.50
Load factor for earthquake loads, EQ (multiplies P_{AE} and P_{IR}):	$\gamma_{p\text{-}EQ}$	1.00

Resistance factor for shear resistance along common interfaces			Static	Combined Static/Seismic
	Reinforced Soil and Foundation	ϕ_{τ}	1.00	1.00
	Reinforced Soil and Reinforcement	ϕ_{τ}	1.00	1.00

Resistance factor for bearing capacity of shallow foundation		Static	Combined Static/Seismic
	ϕ_b	0.65	0.65

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 1.90, factored bearing load = 8083 lb/ft².

Foundation Interface: Direct sliding, CDR = 2.099, Eccentricity, e/L = 0.1628, CDR-overturning = 3.07

METAL STRIP				CONNECTION						
#	Elevation [ft]	Length [ft]	Type #	CDR [connection break]	CDR Strength	Metal strip strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.98	22.40	1					2.146	0.1538	---
2	3.44	22.40	1					2.305	0.1325	---
3	5.91	22.40	1					2.490	0.1126	---
4	8.37	22.40	1					2.706	0.0944	---
5	10.83	22.40	1					2.964	0.0778	---
6	13.29	22.40	1					3.287	0.0627	---
7	15.75	22.40	1					3.679	0.0493	---
8	18.21	22.40	1					4.170	0.0374	---
9	20.67	22.40	1					4.811	0.0271	---
10	23.13	22.40	1					5.685	0.0184	---
11	25.59	22.40	1					6.948	0.0112	---
12	28.05	22.40	1					8.931	0.0056	---
13	30.51	22.40	1					12.500	0.0016	---

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, CDR = 1.14, factored bearing load = 10523 lb/ft².

Foundation Interface: Direct sliding, CDR = 1.414, Eccentricity, e/L = 0.2933, Fs-overturning = 1.70

METAL STRIP				CONNECTION						
#	Elevation [ft]	Length [ft]	Type #	CDR [connection break]	CDR Strength	Metal strip strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.98	22.40	1					1.448	0.2771	---
2	3.44	22.40	1					1.561	0.2383	---
3	5.91	22.40	1					1.693	0.2023	---
4	8.37	22.40	1					1.850	0.1693	---
5	10.83	22.40	1					2.038	0.1393	---
6	13.29	22.40	1					2.277	0.1121	---
7	15.75	22.40	1					2.572	0.0878	---
8	18.21	22.40	1					2.948	0.0664	---
9	20.67	22.40	1					3.454	0.0479	---
10	23.13	22.40	1					4.170	0.0323	---
11	25.59	22.40	1					5.260	0.0196	---
12	28.05	22.40	1					7.121	0.0097	---
13	30.51	22.40	1					11.021	0.0028	---

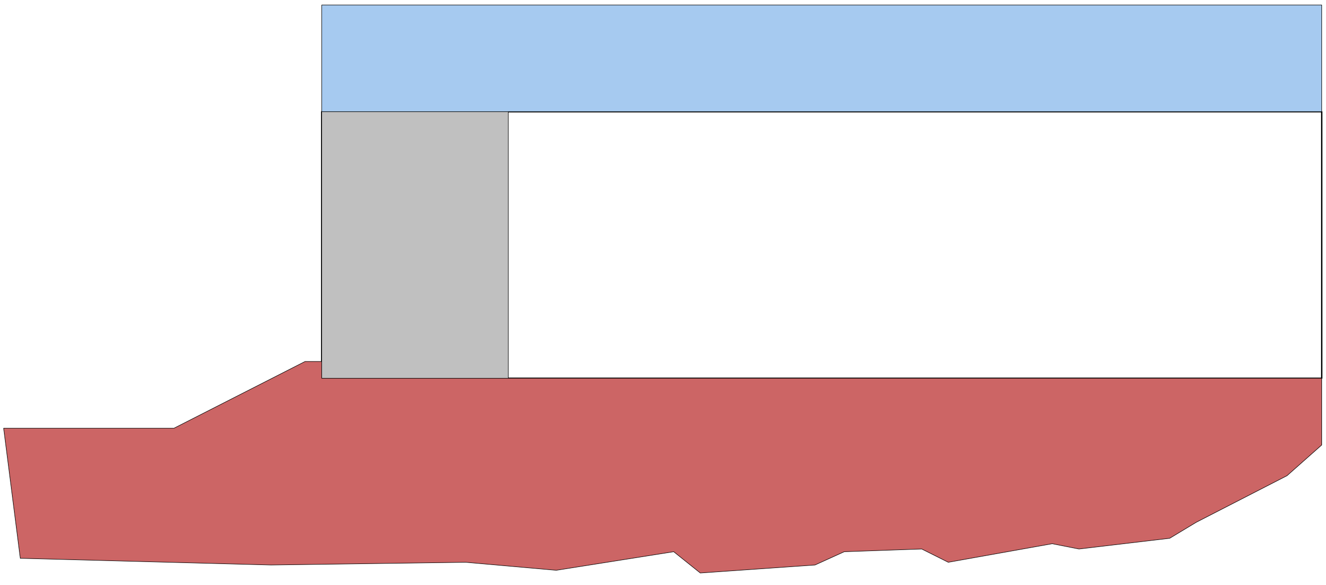
BEARING CAPACITY for GIVEN LAYOUT – Using AASHTO 2017-2020 method

	STATIC	SEISMIC	UNITS
(Water table does not affect bearing capacity)			
Factored bearing resistance. q-n	15368	11965	[lb/ft ²]
Factored bearing load, σ_V	8082.6	10523	[lb/ft ²]
Eccentricity, e	2.51	4.53	[ft]
Eccentricity, e/L	0.112	0.202	
CDR calculated	1.90	1.14	
Base length	22.40	22.40	[ft]

Unfactored applied bearing pressure = (Unfactored R) / [L - 2 * (Unfactored e)] =

Static: Unfactored R = 102367.93 [lb/ft], L = 22.40, Unfactored e = 2.24 [ft], and Sigma = 5711.77 [lb/ft ²]

Seismic: Unfactored R = 102367.93 [lb/ft], L = 22.40, Unfactored e = 4.83 [ft], and Sigma = 8030.53 [lb/ft ²]



SCALE:

0 5 10 15 20 25 30 [ft]

DIRECT SLIDING for GIVEN LAYOUT (for METAL STRIPS reinforcements)

Along reinforced and foundation soils interface: CDR-static = 2.099 and CDR-seismic = 1.414

#	Metal strip Elevation [ft]	Metal strip Length [ft]	CDR Static	CDR Seismic	Metal strip Type #	Product name
1	0.98	22.40	2.146	1.448	1	---
2	3.44	22.40	2.305	1.561	1	---
3	5.91	22.40	2.490	1.693	1	---
4	8.37	22.40	2.706	1.850	1	---
5	10.83	22.40	2.964	2.038	1	---
6	13.29	22.40	3.287	2.277	1	---
7	15.75	22.40	3.679	2.572	1	---
8	18.21	22.40	4.170	2.948	1	---
9	20.67	22.40	4.811	3.454	1	---
10	23.13	22.40	5.685	4.170	1	---
11	25.59	22.40	6.948	5.260	1	---
12	28.05	22.40	8.931	7.121	1	---
13	30.51	22.40	12.500	11.021	1	---

ECCENTRICITY for GIVEN LAYOUT (for Simplified Method)

At interface with foundation: e/L static = 0.1628, e/L seismic = 0.2933; Overturning: CDR-static = 3.07, CDR-seismic = 1.70

#	Metal strip Elevation [ft]	Metal strip Length [ft]	e / L Static	e / L Seismic	Metal strip Type #	Product name
1	0.98	22.40	0.1538	0.2771	1	---
2	3.44	22.40	0.1325	0.2383	1	---
3	5.91	22.40	0.1126	0.2023	1	---
4	8.37	22.40	0.0944	0.1693	1	---
5	10.83	22.40	0.0778	0.1393	1	---
6	13.29	22.40	0.0627	0.1121	1	---
7	15.75	22.40	0.0493	0.0878	1	---
8	18.21	22.40	0.0374	0.0664	1	---
9	20.67	22.40	0.0271	0.0479	1	---
10	23.13	22.40	0.0184	0.0323	1	---
11	25.59	22.40	0.0112	0.0196	1	---
12	28.05	22.40	0.0056	0.0097	1	---
13	30.51	22.40	0.0016	0.0028	1	---

AASHTO 2017-2020
North Valleys I-1093

MSEW+: Update # 2021.14

PROJECT IDENTIFICATION

Title:	North Valleys I-1093
Project Number:	RW 18 Parallel
Client:	NDOT
Designer:	George Helgerson
Station Number:	

Description:

Company's information:

Name: NDOT
Street:

,
Telephone #:
Fax #:
E-Mail:

File path and name: \\datsrv1\028GeoTechnical\00 Projects\74107 395 North V.....
.....SEW I-1093 RW18.BENp

Original date and time of creating this file: Tue Jun 28 13:17:19 2022

PROGRAM MODE: ANALYSIS
of a SIMPLE STRUCTURE
using METAL STRIPS as reinforcing material.

SOIL DATA

REINFORCED SOIL

Unit weight, γ 135.0 lb/ft ³

Design value of internal angle of friction, ϕ 34.0 °

RETAINED SOIL

Unit weight, γ 125.0 lb/ft ³

Design value of internal angle of friction, ϕ 34.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$ 125.0 lb/ft ³

Equivalent internal angle of friction, $\phi_{equiv.}$ 35.0 °

Equivalent cohesion, $c_{equiv.}$ 100.0 lb/ft ²

Water table does not affect bearing capacity

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.2827 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)

Ka (external stability) = 0.2827 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity is controlled by general shear.

Bearing capacity factors (calculated by MSEW): Nc = 10.62 N γ= 11.06

SEISMICITY (using AASHTO 2017-2020)

Peak ground acceleration coeff., A = PGA = 0.500 and Site Factor, Fpga = 1.076. Maximum ground acceleration coeff., As = 0.538

Design acceleration coefficient in Internal Stability: Kh = Am = 0.218

Design acceleration coefficient in External Stability: Kh_d = 0.218 => Kh = Am = 0.218

Kae (Kh > 0) = 0.4240 Kae (Kh = 0) = 0.2827

Seismic soil-metal strip friction coefficient, F* is 80.0% of its specified static value.

INPUT DATA: Geometry and Surcharge loads (of a SIMPLE STRUCTURE)

Design height, Hd 18.00 [ft] { Embedded depth is E = 10.00 ft, and height above top of finished bottom grade is H = 8.00 ft }

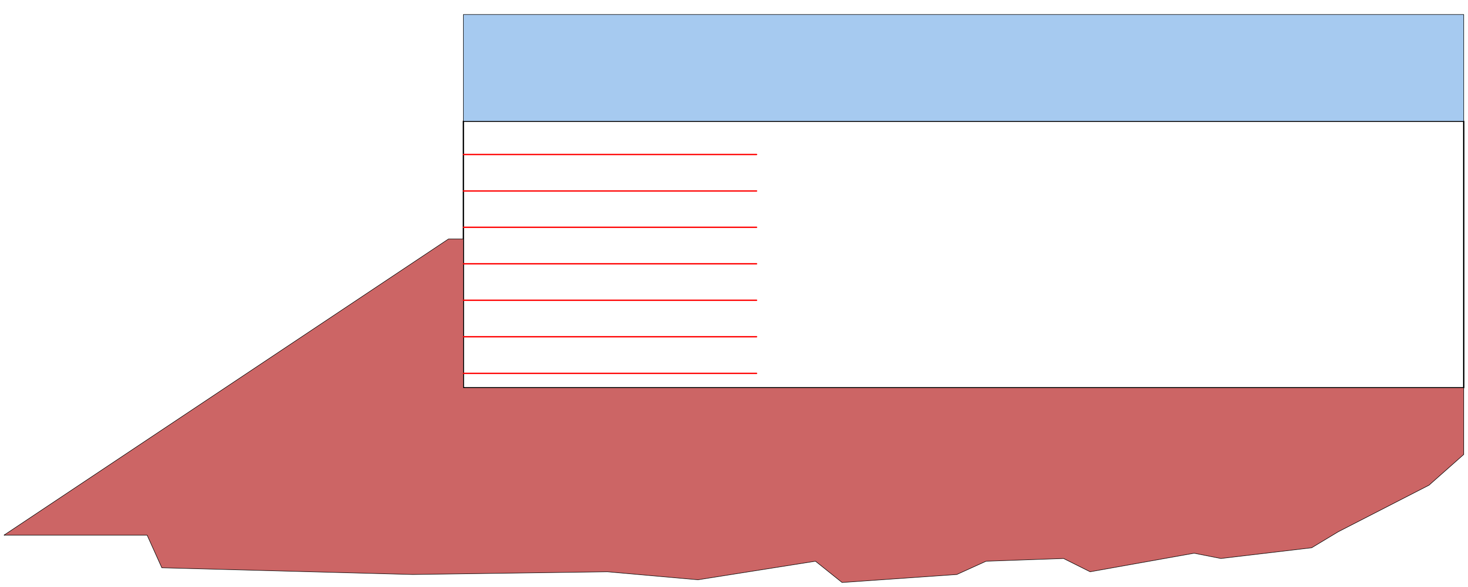
Soil in front of wall is inclined at 33.7°, Hs = 20.00 ft. and bs = 1.00 ft.

Batter, ω	0.0	[deg]	
Backslope, β	0.0	[deg]	
Backslope rise	0.0	[ft]	Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)

U N I F O R M S U R C H A R G E

Uniformly distributed dead load is 0.0 [lb/ft ²], and live load is 250.0 [lb/ft ²]

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 [ft]

AASHTO 2017-2020 – Load and Resisting Factors

EXTERNAL STABILITY

Load factor for vertical earth pressure, EV		Static	Combined Static/Seismic	
Sliding and Eccentricity	$\gamma_{p\text{-}EV}$	1.00	$\gamma_{p\text{-}EQ}$	1.00
Bearing Capacity	$\gamma_{p\text{-}EV}$	1.35	$\gamma_{p\text{-}EQ}$	1.35

Load factor of active lateral earth pressure, EH	$\gamma_{p\text{-}EH}$	1.50
Load factor of active lateral earth pressure during earthquake (does not multiply P_{AE} and P_{IR}):	$(\gamma_{p\text{-}EH})_{EQ}$	1.50
Load factor for earthquake loads, EQ (multiplies P_{AE} and P_{IR}):	$\gamma_{p\text{-}EQ}$	1.00

Resistance factor for shear resistance along common interfaces		Static	Combined Static/Seismic
Reinforced Soil and Foundation	ϕ_τ	1.00	1.00
Reinforced Soil and Reinforcement	ϕ_τ	1.00	1.00

Resistance factor for bearing capacity of shallow foundation		Static	Combined Static/Seismic
	ϕ_b	0.65	0.65

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 2.11, factored bearing load = 4123 lb/ft².

Foundation Interface: Direct sliding, CDR = 3.001, Eccentricity, e/L = 0.0751, CDR-overturning = 6.66

#	METAL STRIP Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection break]	CDR Strength	Metal strip strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.98	19.80	1					3.137	0.0682	---
2	3.44	19.80	1					3.538	0.0524	---
3	5.91	19.80	1					4.060	0.0385	---
4	8.37	19.80	1					4.758	0.0267	---
5	10.83	19.80	1					5.747	0.0170	---
6	13.29	19.80	1					7.255	0.0092	---
7	15.75	19.80	1					9.835	0.0035	---

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, CDR = 1.78, factored bearing load = 4508 lb/ft².

Foundation Interface: Direct sliding, CDR = 2.084, Eccentricity, e/L = 0.1341, Fs-overturning = 3.73

#	METAL STRIP Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection break]	CDR Strength	Metal strip strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.98	19.80	1					2.186	0.1217	---
2	3.44	19.80	1					2.492	0.0932	---
3	5.91	19.80	1					2.900	0.0682	---
4	8.37	19.80	1					3.464	0.0471	---
5	10.83	19.80	1					4.302	0.0297	---
6	13.29	19.80	1					5.674	0.0160	---
7	15.75	19.80	1					8.332	0.0059	---

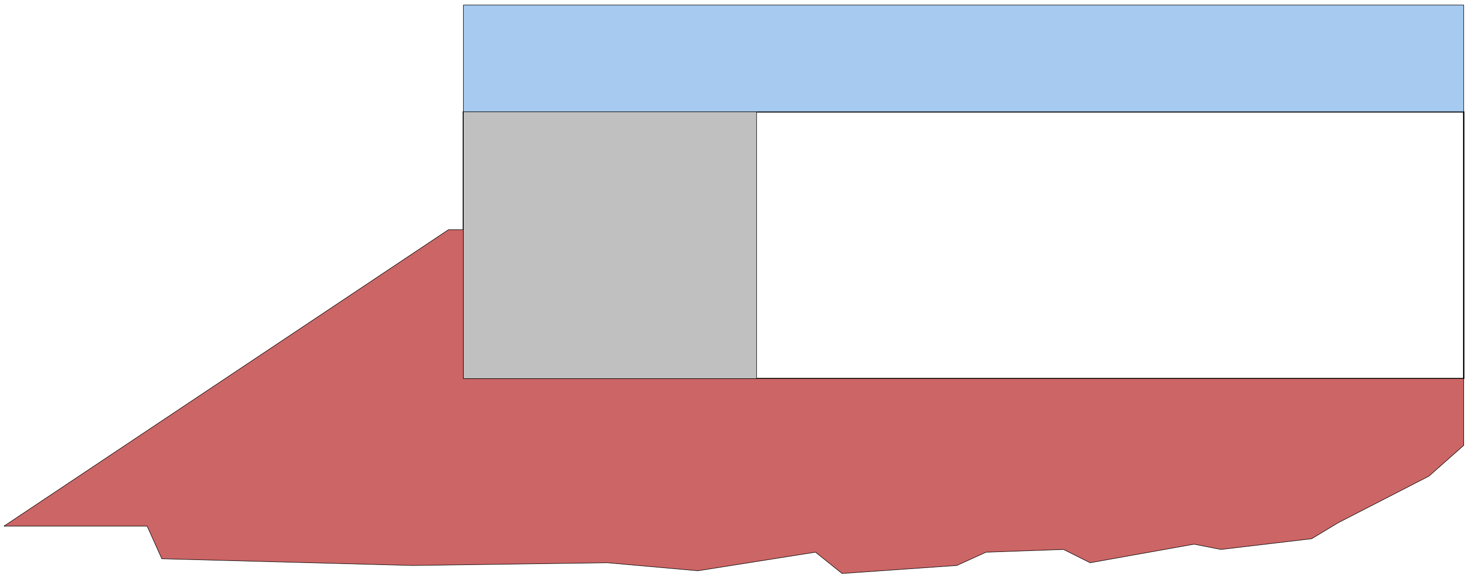
BEARING CAPACITY for GIVEN LAYOUT – Using AASHTO 2017-2020 method

	STATIC	SEISMIC	UNITS
(Water table does not affect bearing capacity)			
Factored bearing resistance. q-n	8713	8027	[lb/ft ²]
Factored bearing load, σ_V	4122.8	4508	[lb/ft ²]
Eccentricity, e	0.97	1.74	[ft]
Eccentricity, e/L	0.049	0.088	
CDR calculated	2.11	1.78	
Base length	19.80	19.80	[ft]

Unfactored applied bearing pressure = (Unfactored R) / [L - 2 * (Unfactored e)] =

Static: Unfactored R = 53063.97 [lb/ft], L = 19.80, Unfactored e = 0.86 [ft], and Sigma = 2935.96 [lb/ft ²]

Seismic: Unfactored R = 53063.97 [lb/ft], L = 19.80, Unfactored e = 1.81 [ft], and Sigma = 3281.40 [lb/ft ²]



SCALE:

0 2 4 6 [ft]

DIRECT SLIDING for GIVEN LAYOUT (for METAL STRIPS reinforcements)

Along reinforced and foundation soils interface: CDR-static = 3.001 and CDR-seismic = 2.084

#	Metal strip Elevation [ft]	Metal strip Length [ft]	CDR Static	CDR Seismic	Metal strip Type #	Product name
1	0.98	19.80	3.137	2.186	1	---
2	3.44	19.80	3.538	2.492	1	---
3	5.91	19.80	4.060	2.900	1	---
4	8.37	19.80	4.758	3.464	1	---
5	10.83	19.80	5.747	4.302	1	---
6	13.29	19.80	7.255	5.674	1	---
7	15.75	19.80	9.835	8.332	1	---

ECCENTRICITY for GIVEN LAYOUT (for Simplified Method)

At interface with foundation: e/L static = 0.0751, e/L seismic = 0.1341; Overturning: CDR-static = 6.66, CDR-seismic = 3.73

#	Metal strip Elevation [ft]	Metal strip Length [ft]	e / L Static	e / L Seismic	Metal strip Type #	Product name
1	0.98	19.80	0.0682	0.1217	1	---
2	3.44	19.80	0.0524	0.0932	1	---
3	5.91	19.80	0.0385	0.0682	1	---
4	8.37	19.80	0.0267	0.0471	1	---
5	10.83	19.80	0.0170	0.0297	1	---
6	13.29	19.80	0.0092	0.0160	1	---
7	15.75	19.80	0.0035	0.0059	1	---

AASHTO 2017-2020
North Valleys I-1093

MSEW+: Update # 2021.14

PROJECT IDENTIFICATION

Title:	North Valleys I-1093
Project Number:	RW 19 Parallel
Client:	NDOT
Designer:	George Helgerson
Station Number:	

Description:

Company's information:

Name: NDOT
Street:

,
Telephone #:
Fax #:
E-Mail:

File path and name: \\datsrv1\028GeoTechnical\00 Projects\74107 395 North V.....
.....SEW I-1093 RW19.BENp

Original date and time of creating this file: Tue Jun 28 13:17:19 2022

PROGRAM MODE: ANALYSIS
of a SIMPLE STRUCTURE
using METAL STRIPS as reinforcing material.

SOIL DATA

REINFORCED SOIL

Unit weight, γ	135.0 lb/ft ³
Design value of internal angle of friction, ϕ	34.0 °

RETAINED SOIL

Unit weight, γ	125.0 lb/ft ³
Design value of internal angle of friction, ϕ	34.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	125.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{equiv.}$	35.0 °
Equivalent cohesion, $c_{equiv.}$	100.0 lb/ft ²

Water table does not affect bearing capacity

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.2827 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Ka (external stability) = 0.2827 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity is controlled by general shear.
Bearing capacity factors (calculated by MSEW): Nc = 8.42 $N\gamma$= 8.76

SEISMICITY (using AASHTO 2017-2020)

Peak ground acceleration coeff., A = PGA = 0.500 and Site Factor, Fpga = 1.076. Maximum ground acceleration coeff., As = 0.538
Design acceleration coefficient in Internal Stability: Kh = Am = 0.218
Design acceleration coefficient in External Stability: Kh_d = 0.218 => Kh = Am = 0.218

Kae (Kh > 0) = 0.4240 Kae (Kh = 0) = 0.2827
Seismic soil-metal strip friction coefficient, F* is 80.0% of its specified static value.

INPUT DATA: Geometry and Surcharge loads (of a SIMPLE STRUCTURE)

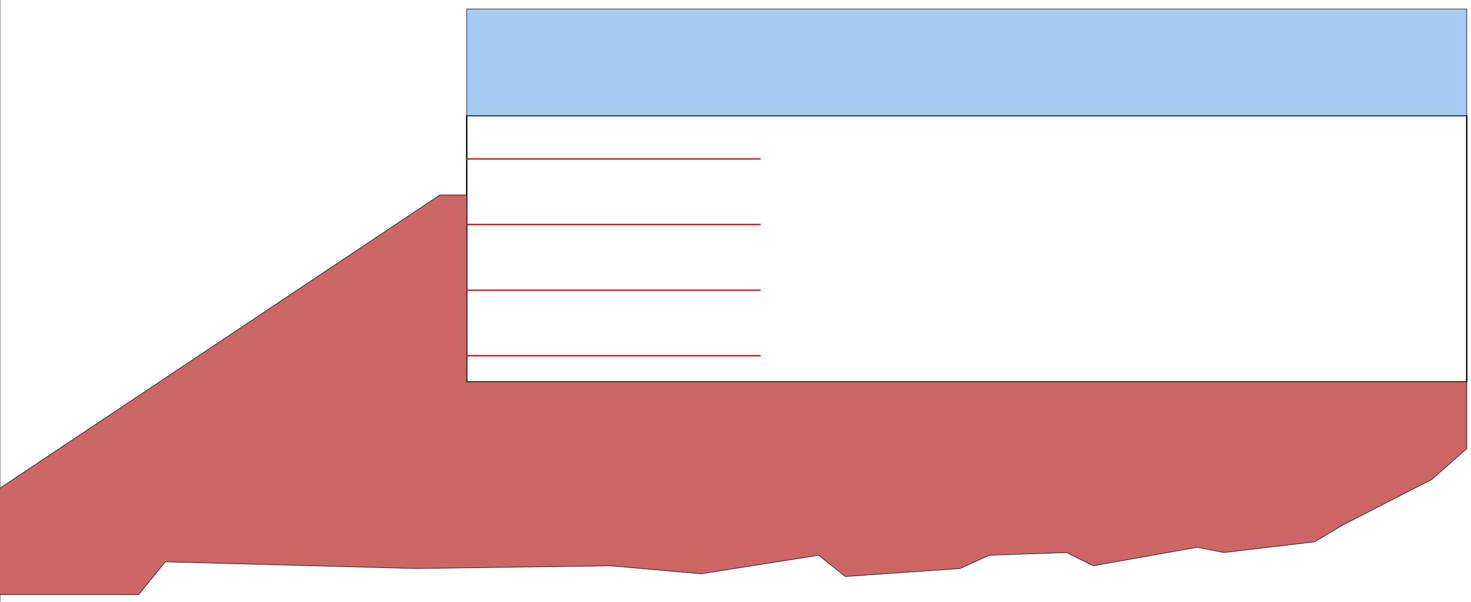
Design height, Hd 10.00 [ft] { Embedded depth is E = 7.00 ft, and height above top of finished bottom grade is H = 3.00 ft }
Soil in front of wall is inclined at 33.7°, Hs = 15.00 ft. and bs = 1.00 ft.

Batter, ω	0.0	[deg]	
Backslope, β	0.0	[deg]	
Backslope rise	0.0	[ft]	Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)

U N I F O R M S U R C H A R G E

Uniformly distributed dead load is 0.0 [lb/ft ²], and live load is 250.0 [lb/ft ²]

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 [ft]

AASHTO 2017-2020 – Load and Resisting Factors

EXTERNAL STABILITY

			Static		Combined Static/Seismic
Load factor for vertical earth pressure, EV					
	Sliding and Eccentricity	$\gamma_{p\text{-}EV}$	1.00	$\gamma_{p\text{-}EQ}$	1.00
	Bearing Capacity	$\gamma_{p\text{-}EV}$	1.35	$\gamma_{p\text{-}EQ}$	1.35

Load factor of active lateral earth pressure, EH	$\gamma_{p\text{-}EH}$	1.50
Load factor of active lateral earth pressure during earthquake (does not multiply P_{AE} and P_{IR}):	$(\gamma_{p\text{-}EH})_{EQ}$	1.50
Load factor for earthquake loads, EQ (multiplies P_{AE} and P_{IR}):	$\gamma_{p\text{-}EQ}$	1.00

			Static	Combined Static/Seismic
Resistance factor for shear resistance along common interfaces				
	Reinforced Soil and Foundation	ϕ_τ	1.00	1.00
	Reinforced Soil and Reinforcement	ϕ_τ	1.00	1.00

		Static	Combined Static/Seismic
Resistance factor for bearing capacity of shallow foundation			
	ϕ_b	0.65	0.65

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 1.59, factored bearing load = 2539 lb/ft².

Foundation Interface: Direct sliding, CDR = 2.577, Eccentricity, e/L = 0.0919, CDR-overturning = 5.44

METAL STRIP #	Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection break]	CDR Strength	Metal strip strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.98	11.00	1					2.761	0.0782	---
2	3.44	11.00	1					3.366	0.0481	---
3	5.91	11.00	1					4.316	0.0245	---
4	8.37	11.00	1					6.002	0.0076	---

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, CDR = 1.32, factored bearing load = 2803 lb/ft².

Foundation Interface: Direct sliding, CDR = 1.759, Eccentricity, e/L = 0.1622, Fs-overturning = 3.08

METAL STRIP #	Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection break]	CDR Strength	Metal strip strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.98	11.00	1					1.859	0.1375	---
2	3.44	11.00	1					2.150	0.0840	---
3	5.91	11.00	1					2.473	0.0424	---
4	8.37	11.00	1					2.425	0.0129	---

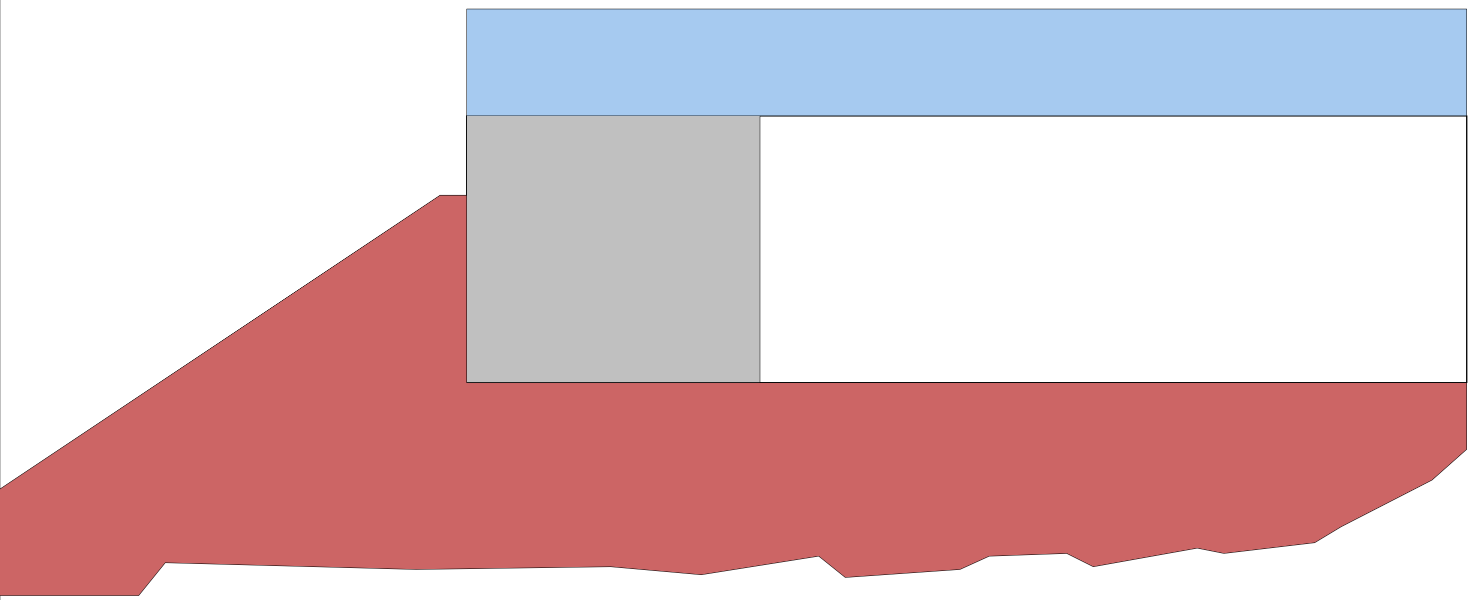
BEARING CAPACITY for GIVEN LAYOUT – Using AASHTO 2017-2020 method

	STATIC	SEISMIC	UNITS
(Water table does not affect bearing capacity)			
Factored bearing resistance. q-n	4033	3704	[lb/ft ²]
Factored bearing load, σ_V	2538.9	2803	[lb/ft ²]
Eccentricity, e	0.60	1.07	[ft]
Eccentricity, e/L	0.055	0.097	
CDR calculated	1.59	1.32	
Base length	11.00	11.00	[ft]

Unfactored applied bearing pressure = (Unfactored R) / [L - 2 * (Unfactored e)] =

Static: Unfactored R = 17599.99 [lb/ft], L = 11.00, Unfactored e = 0.54 [ft], and Sigma = 1772.57 [lb/ft ²]

Seismic: Unfactored R = 17599.99 [lb/ft], L = 11.00, Unfactored e = 1.09 [ft], and Sigma = 1994.00 [lb/ft ²]



SCALE:

0 2 4 6 [ft]

DIRECT SLIDING for GIVEN LAYOUT (for METAL STRIPS reinforcements)

Along reinforced and foundation soils interface: CDR-static = 2.577 and CDR-seismic = 1.759

#	Metal strip Elevation [ft]	Metal strip Length [ft]	CDR Static	CDR Seismic	Metal strip Type #	Product name
1	0.98	11.00	2.761	1.859	1	---
2	3.44	11.00	3.366	2.150	1	---
3	5.91	11.00	4.316	2.473	1	---
4	8.37	11.00	6.002	2.425	1	---

ECCENTRICITY for GIVEN LAYOUT (for Simplified Method)

At interface with foundation: e/L static = 0.0919, e/L seismic = 0.1622; Overturning: CDR-static = 5.44, CDR-seismic = 3.08

#	Metal strip Elevation [ft]	Metal strip Length [ft]	e / L Static	e / L Seismic	Metal strip Type #	Product name
1	0.98	11.00	0.0782	0.1375	1	---
2	3.44	11.00	0.0481	0.0840	1	---
3	5.91	11.00	0.0245	0.0424	1	---
4	8.37	11.00	0.0076	0.0129	1	---

NEVADA DEPARTMENT OF TRANSPORTATION

Materials Division
Geotechnical Section
1263 Stewart St, Carson City, NV 89712