U.S. Department of Transportation
Federal Highway Administration

Technical Memorandum

Date: January 4, 2023

To: Michael Daigler, Project Manager, CFLHD, Lakewood, CO

From: James Arthurs, Acting Lead Geotechnical Engineer, CFLHD, Lakewood, CO

Through: James Arthurs, Acting Lead Geotechnical Engineer, CFLHD, Lakewood, CO

Subject: Geotechnical Field Reconnaissance and Recommendations, Nacimiento-Ferguson Road (Forest Road 22S01)

1.0 PROJECT BACKGROUND INFORMATION

This geotechnical memorandum presents the field evaluation results, analyses, and recommendations for the reconstruction of Forest Road 22S01 (Nacimiento-Ferguson Road). The roadway was damaged during heavy rainfall events in January 2021 following the Dolan Fire that burned approximately 128,000 acres of land in the Coastal Ranges. The heavy rainfall led to widespread landslides and debris flows in the project area. Roadway repairs are planned as part of the Emergency Relief for Federally Owned Roads (ERFO) program.

The CA ERFO 22S01(1) Project is in Monterey County, California, within the Los Padres National Forest (Figure 1). The site is located approximately 9 miles west of the community of Jolon, California. The road starts at a junction with Mission Road near the Fort Hunter-Ligget Army Base and continues 22 miles west to a terminus intersection with California Highway 1. Based on discussions with U.S. Forest Service personnel, and interpretation of the failure areas, we understand that recent wildfires combined with heavy rains lead to various slope and culvert failures along the project route.

A total of 16 sites were identified in Detailed Damage Inspection Reports (DDIR) prepared by the Los Padres National Forest (LPNF). Of these, 12 sites were identified by the Central Federal Lands Highway Division (CFLHD) of the Federal Highway Administration (FHWA) as ERFO eligible damage sites. A general project site map showing the locations of all damage sites identified by LPNF is presented in Figure 2. Note that Sites 5 and 6 identified on this figure will be combined into a single site for plan development and construction.

The roadway is surfaced with asphalt pavement. Traffic counts were not available, but conversations with LPNF indicate that this roadway is an important connection between California SR 1 on the west and the population centers in the Salinas Valley on the east. At the time of the scoping site visit (September 2021), the roadway was closed to public traffic. At the time of the 70% plan review (November 2022), the road remained closed to the general public, but access was allowed for local residents and administrative access.

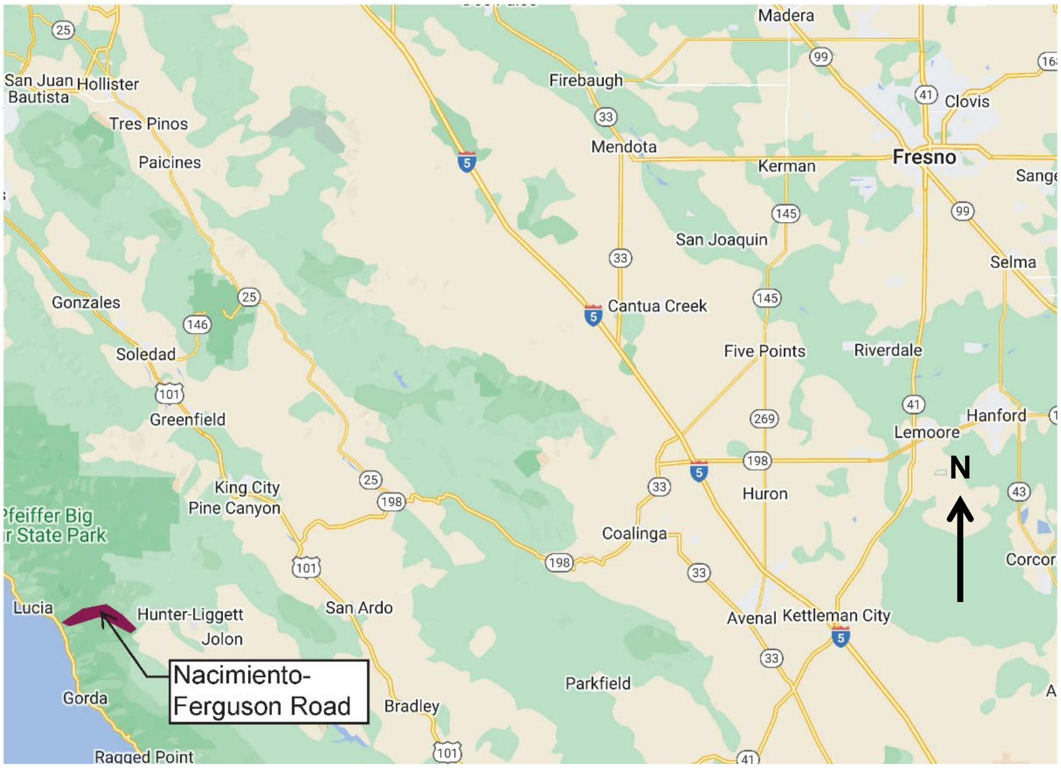


Figure 1: Project Location Map

Figure 2: Site Location Map

2.0 GEOLOGY AND SEISMICITY

2.1 Regional and Local Geology

The project is located in the California Coast Ranges Section of the Pacific Border Province. The region is underlain by a series of complexly folded, faulted, and metamorphosed rocks of the Salinian, Franciscan, and Great Valley Complexes. The site is mapped as underlain by unnamed (Ku) and undifferentiated strata (Km) of the Salinian Complex, and Serpentinite (Jsp) of the Coast Range Ophiolite of the Great Valley Complex (Graymer et al., 2014) and unnamed marine sandstone (Kss) and Granodiorite-quartz diorite of Bear Mountain (Kgdb), quartzofeldspathic ($M_zP_z$qf), and Coast Ridge belt (M_zP_zc) members of the Salinian Complex (Rosenberg and Wills, 2016). A map of the regional geology is presented in Figure 3.

These units include sheared and metamorphosed units that are known to be highly variable over relatively short distances. Weathering and alteration of these units is also known to be highly variable.

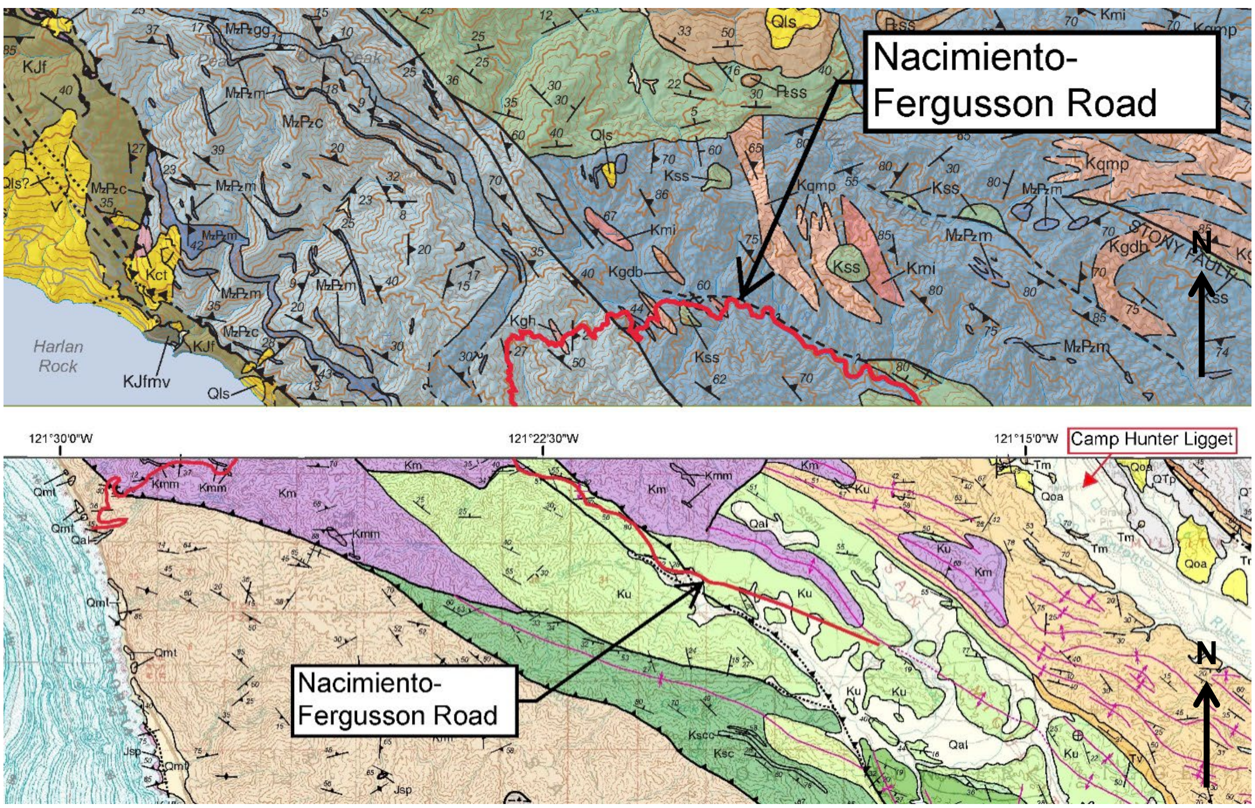


Figure 3(a) and (b): Mapped Geology in the Nacimiento-Fergusson Road project area.

2.2 Seismicity

Several known seismic source faults are mapped within approximately 40 miles of the project area and are summarized in Table 1 below (CalTrans, 2022, U.S. Geological Survey, 2022a,b).

The American Association of State Highway and Transportation Officials (AASHTO) criteria for recommended seismic response parameters are based on the AASHTO LRFD Bridge Design Specifications, 9th Edition, 2020, and represents horizontal peak ground acceleration (PGA) with a 7 percent probability of exceedance in 75 years (approximate 1,000-year return period). The 1,000-year return period uniform hazard spectrum for the approximate center of the Nacimiento-Fergusson Road project (36.011232° N latitude and 121.454826° W longitude) was obtained in accordance with the AASHTO ground motion maps. The site was classified as "Class C" according to site class definitions specified in Table 3.10.3.1-1 of AASHTO and soil profile assumptions based on identification of shallow bedrock throughout most of the project site. The recommended spectral acceleration coefficient values for probabilistic design are summarized on Table 2.

Table 1: Summary of Nearby Seismic Source Faults

FAULT OR FAULT ZONE	**DISTANCE FROM CENTER OF PROJECT** *(miles)*	**FAULT PARALLEL SLIP RATE** *(inch/year)*	**FAULT LENGTH** *(miles)*	**AGE** *(years)*
Hosgri Fault	7.12	0.55	60.27	< 15,000
Rinconada Fault Zone	17.03	0.39	75.81	< 130,000
San Gregorio Fault Zone	18.33	0.53	149.75	< 15,000
Monterey Bay-Tularcitos Fault Zone	23.59	0.20	52.20	< 15,000
Oceanic-West Huasna Fault Zone	26.51	-	-	< 130,000
San Andreas Fault Zone	36.28	8.66	672.32	< 15,000
Calaveras South - Paicines Extension	38.7	5.51	96.93	< 15,000

- Data not included in USGS Quaternary Faults Database.

Table 2: Summary of Seismic Parameters Corrected for Site Class C

Peak Seismic Ground Acceleration Coefficient (A_s)	0.39
Horizontal Response Spectral Acceleration at Period of 0.2 sec (S_{DS})	0.92
Horizontal Response Spectral Acceleration at Period of 1.0 sec (S_{D1})	0.43
Site Factor at Zero-Period of Acceleration Spectrum (F_{PGA})	1.043
Site Factor at Short-Period of Acceleration Spectrum (F_a)	1.069
Site Factor at Long-Period Range of Acceleration Spectrum (F_v)	1.492

Based on the long acceleration coefficient S_{D1} value of 0.43, the site is assigned to Seismic Hazard Zone 3, in accordance with Table 3.10.6-1 of AASHTO.

3.0 FIELD EVALUATION

To evaluate the field conditions, a CFLHD team visited the project site and conducted limited field measurements and observations on September 8 and 9, 2021. This team included Lorell Dutiel (ERFO Coordinator), Thomas McCrary (Roadway Design Engineer), Aaron Estep (Hydraulics Engineer), Timberley Belish (Environmental Protection Specialist), and James Arthurs (Geotechnical Engineer). The CFLHD team met with representatives of the U.S. Forest Service and Los Padres National Forest.

Field observations by the Geotechnical Engineer focused on evaluating the existing roadway conditions and soil properties. Evaluations and recommendations presented in this memorandum are based on visual observations and the limited measurements taken during the site visit. Due to ERFO project time and budget constraints to expedite project delivery and reestablish roadway access, no subsurface investigations were conducted. Samples of the overburden soil material were collected from the project area by James Arthurs and shipped to the CFLHD lab for testing. All samples were collected from the surface using hand tools. Samples at MP 15.02 and 18.53 were collected from the existing cut slope. The sample at MP 9.31 was collected from stockpiled debris materials that had previously been removed from the roadway by USFS maintenance personnel. Results of the testing are presented in Table 3 and Table 4 below. Detailed lab results are attached to this memorandum. Design analyses were based on the lab testing results and presumptive properties and experience from similar repairs.

Table 3: Classification Testing Results

MILEPOST[1]	OFFSET	PERCENT SAND	PERCENT PASSING 200	LL	PI	USCS	AASHTO
9.31	LT	66	11	NV	NP	SP-SM	A-1-b(0)
15.02	RT	52	2.4	NV	NP	SP	A-1-a(0)
18.53	RT	40	1.9	NV	NP	GW	A-1-a(0)

[1] Estimated milepost is based on MP 0.0 at intersection of Nacimiento-Fergusson Road and Mission Road

Table 4: Engineering and Chemical Properties Testing Results

MILEPOST[1]	OFFSET	MAXIMUM DRY DENSITY[2] *(pcf)*	OPTIMUM MOISTURE CONTENT[2] *(%)*	LA ABRASION *(% loss)*	pH	RESISTIVITY *(ohm-cm)*
9.31	LT	126.1	8.6	-	7.1	5,040
15.02	RT	-	-	44	6.9	7,960
18.53	RT	122.5	11.6	75	6.8	8,620

[1] Estimated milepost is based on MP 0.0 at intersection of Nacimiento-Fergusson Road and Mission Road
[2] Samples contained a high percentage of oversize particles. Reported results are for material passing the No. 4 sieve. See attached lab results for details.

Figure 4: Typical Roadway Section near MP 9.34

The Nacimiento-Fergusson Road appears to have been constructed using conventional cut and sidecast fill techniques as shown on Figure 4 and Figure 5. Cut slopes for the roadway vary between 1V:1H for rock and 1V:1.5H to 1V:2:H for soil. Native slopes in the area are typically

Figure 6: Typical Roadway Section near MP 18.53

Figure 5: Highly weathered rock near MP 18.37

vegetated with deciduous trees and brush or undergrowth, while cut and fill slopes are grassy with isolated bushes. Areas of exposed bedrock are generally bare and unvegetated. Undisturbed areas were generally mantled in a layer of residual soil, with local bedrock outcrops. Local instability or raveling was noted in the existing bedrock cut slopes, but appeared to be limited to a maintenance level issue. This raveling is limited to small (less than 6-inch maximum dimension) particles that do not pose a significant safety hazard. Bedrock exposed in cut slopes was varied from slightly to highly weathered. Where less weathered, the intact rock was moderately strong to very strong. Where highly weathered, open, soil-filled joints dominate the rock-mass properties (Figure 6).

Site observations and repair recommendations are summarized in Table 5. Photos of the sites are attached to this memorandum.

Table 5: Site Observations and Repair Recommendations

Site[1,2]	MP[3]	Site Description	Proposed Repair
BA 7	9.31	Approximately 20% of material is boulders 12" or larger, 40% is material greater than 6". Potentially to be used for gabion or MSE facing fill. Total 450 CY of debris.	
1	9.34	Deposition point for debris flows from canyon. Not ERFO eligible.	
BA 6	10.52	Approximately 20% of material is boulders 12" or larger, likely about 10 CY of larger rocks. Rock is hard and chips under hammer point (R5-R6).	
2	13.29	Culvert over-topped and eroded embankment, 100' long erosion.	Replace embankment.
3	14.38	Culvert over-topped and eroded embankment.	Replace culvert, RSS to limit channel constriction
4	14.58	Culvert over-topped, water scoured embankment, 4' high scarp, 30' long. Rock in cut slope.	MSE Wall
5	14.74	Combine Sites 5 and 6. Debris flow in large channel with 5' of debris deposited on roadway. Material collected for potential borrow source. Scour and failure of embankment, 115' long.	Conventional embankment, replace culvert.
6	14.75		
7	14.77	No roadway damage, not ERFO eligible.	
8	14.83	Embankment failure, 4’ high scarp, 60’ long.	MSE Wall

Site[1,2]	MP[3]	Site Description	Proposed Repair
8b	14.87	Buried culvert, maintenance issue, not ERFO eligible.	
8a	15	Not ERFO eligible, 6' high, 100' long scarp. Hard rock in cut slope.	
BA 5	15.02	-	
9	15.08	Not ERFO eligible, erosion of soil in front of dry stack rock wall.	
10	15.28	Erosion around culvert, 6' high, 350' long scarp.	MSE Wall
11	15.73	Embankment failure, 3' high scarp, 50' wide. Located near water tank. Highly weather rock in adjacent cut slope.	Reconstruct embankment, RSS to limit channel impacts
12	16.66	Embankment failure / culvert overtopping. Fill slope eroded.	Add/Replace culvert, reconstruct embankment.
13	16.94	Embankment failure, 5' high scarp, 30' long. Silty sand and gravel. Bedrock in adjacent cut slope.	MSE Wall
14	17.13	Embankment failure, 10' high scarp, 30' wide. Slope below failure is about 1:1.5.	MSE Wall
14a	17.29	Not ERFO eligible. Erosion of outboard slope.	Small RSS or Deep Patch.
15	17.49	Embankment failure, 11' high scarp, 25' wide. Rock visible below roadway.	MSE Wall
BA 4	17.68	Weathered metamorphic rock	
BA 3	18.26	Weathered metamorphic rock	
BA 2	18.37	Weathered metamorphic rock	
BA 1	18.53	20' high slope, weathered metamorphic rock, vehicle pullout on outboard side	
16	18.59	Embankment failure, 8' high scarp, 75' wide.	MSE Wall

[1] BA indicates potential borrow area, subject to environmental clearance.

[2] Observations included for non-ERFO eligible sites for information only; no design performed for these sites.

[3] Estimated milepost is based on MP 0.0 at intersection of Nacimiento-Fergusson Road and Mission Road

4.0 ANALYSIS

4.1 Slope Stability

Slope stability analysis was completed for the failed embankments at Site 4, 8, 10, 13, 14, 15, and 16. Back calculation analyses for slope conditions at failure were first conducted using the Slide 7.0 computer program developed by RocScience. Slide 7.0 uses limit equilibrium methods to determine the factors of safety for slope stability. The back-analyzed soil parameters were then used for retaining wall design calculations.

Presumptive soil properties at each location were estimated based on laboratory testing, visual classification, and experience with similar soil materials for initial input in the back analysis. Based on the recent fire activity and heavy precipitation events leading to the roadway embankment damage, groundwater levels were assumed to be relatively shallow at the time of failure. An incipient static factor of safety of unity was used to refine the estimated soil parameters. Conservative, presumptive properties for existing embankment materials were assigned based on visual classification and experience with similar materials.

Bedrock was observed both in the existing roadway cut slopes and in the native slopes below the embankment. Global stability analysis of the sites therefore included bedrock at various depths below the road surface depending on observations at each site. The depth to bedrock is a conservative assumption for slope stability analysis and does not necessarily reflect the actual subsurface profile. Difficult excavation conditions may be expected. Recommendations regarding excavation in bedrock are presented in Section 5, below.

Slope geometry was based on roadway design cross-sections prepared from topographic survey collected by CFLHD, dated July 5, 2022.

The back-analyzed and assumed soil and rock parameters were used in further analyses to examine the effectiveness of repair options and are summarized in Table 6 below. Results of the slope stability analyses are attached to this memorandum.

Table 6: Material Properties Used in Wall Design.

SOIL TYPE	UNIT WEIGHT (*pcf*)	FRICTION ANGLE (*degrees*)	COHESION (*psf*)
All Sites			
Select Granular Backfill	125	34	0
RSS Backfill	125	32	0
Sites 3, 4, 8, 10, 16			
On-Site Soil / Fill	120	32	100

SOIL TYPE	UNIT WEIGHT (*pcf*)	FRICTION ANGLE (*degrees*)	COHESION (*psf*)
Weathered Bedrock	130	32	200
Bedrock	140	32	500
Site 13			
On-Site Soil / Fill	120	36	100
Weathered Bedrock	130	36	200
Bedrock	140	36	500
Site 14			
On-Site Soil / Fill	120	33	100
Weathered Bedrock	130	32	200
Bedrock	140	32	500
Site 15			
On-Site Soil / Fill	120	32	50
Weathered Bedrock	130	32	200
Bedrock	130	32	500

4.2 Mechanically Stabilized Earth Wall Design Analyses

MSE walls are earth retaining structures constructed of soil reinforcing elements (either steel or geosynthetic) placed in a high quality backfill material. These structures rely on the soil reinforcement to create a coherent mass to resist the lateral pressures imposed by materials behind the reinforced fill. MSE walls have been utilized on many projects as context sensitive solutions preserving scenic, aesthetic, historic, and environmental resources.

4.2.1 Analysis Procedures

Based on the observed conditions and to comply with the ERFO objectives to restore the roadway to acceptable and safe conditions within budget, a Mechanically Stabilized Earth (MSE) retaining wall was analyzed as the preferred repair alternative for Sites 4, 8, 10, 13, 14, 15, and 16. A near vertical retaining wall system is expected to best meet the project requirements based on the existing site conditions, steep existing slopes, and the proposed roadway widths. An MSE system is likely the most cost-effective retaining wall system for the proposed application.

The MSE walls were designed as gravity retaining walls based on the proposed typical roadway section and cross sections prepared by the CFLHD Roadway Engineer. Table 7 presents a summary of the analyzed wall geometries. The MSEW software package published by ADAMA Engineering was used to check external (sliding, overturning, and bearing resistance) stability for the walls. Slide2, published by RocScience, was used to check global stability. Global stability analyses in Slide2 used the Morgenstern-Price method to calculate overall factors of safety for slope or retaining wall stability.

Table 7: Wall Geometries Analyzed in MSEW

MAXIMUM DESIGN HEIGHT	MINIMUM REINFORCEMENT LENGTH FOR EXTERNAL STABILITY	REINFORCEMENT TYPES (FP-14, 714.04)[1]
6 ft	8.0 ft	(3) Type II
8 ft	9.5 ft	(4) Type II
10 ft	11.0 ft	(5) Type II
12 ft	12.5 ft	(6) Type II
14 ft	14.0 ft	(5) Type II (2) Type III
16 ft	16.0 ft	(5) Type II (3) Type III
18 ft	17.5 ft	(4) Type II (3) Type III (2) Type IV

[1]Reinforcement types provided for information only. Internal stability analysis to be performed by contractor according to Section 257.

Preliminary external design including global stability, bearing resistance, sliding, overturning, and eccentricity was performed to evaluate the proposed wall geometry. The final MSE wall internal stability will be designed and submitted by the contractor. The walls were designed in general accordance with the AASHTO LRFD Bridge Design Specifications 9th Edition including interim revisions, and FHWA Publication NHI-10-024 and NHI-10-025, Volumes 1 and 2, respectively, entitled “Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes” dated November 2009. Acceptance criteria used for preliminary design are shown in Table 8.

The capacity to demand ratios (CDR) for bearing resistance and sliding are used to quantify the ratio of the factored resistance to the factored load. Resistance factors of 0.65 and 1.00 were used in preliminary design for bearing and sliding, respectively. Load factors for bearing, sliding, and eccentricity are shown in Tables 4-1 and 4-2 of FHWA (2009). Seismic stability was considered in the preliminary analyses using 50% of A_s for the horizontal acceleration.

Table 8: MSE Wall Design Minimum Acceptance Criteria

STABILITY MODE	MINIMUM ACCEPTANCE CRITERIA
Global Stability	*FS = 1.30 (static) 1.10 (seismic)
Bearing Resistance	CDR = 1.0
Sliding	CDR = 1.0
Limiting Eccentricity	e_{max} = L/4

Notes: FS = Factor of Safety, CDR = Capacity to Demand Ratio, Eccentricity (e_{max}) for soil foundations.
*See discussion in following this table

In general, the existing slopes at the project site are very steep (between 1V:1H and 1V:1.5H) and interpreted to be quasi-stable under static conditions and unstable under the design seismic loading. Depth to bedrock below the roadway is not certain and has a high impact on the calculated factors of safety. Analysis of global stability for the MSE walls therefore evaluated both the reinforcing length required to meet the minimum acceptable global factor of safety, and the AASHTO defined minimum reinforcement length (8 feet or 70% of wall height, whichever is greater). Due to the quasi-stable nature of the slopes, a minimum global static factor of safety of 1.3 was not considered as the primary acceptance criteria. Instead, we evaluated the change in static and seismic factors of safety between the backanalysis case and the proposed wall geometry. Improvement in the static factor of safety and a reduction of less than 0.05 in the seismic factor of safety were considered acceptable.

4.2.2 Analysis Results

Calculated capacity-demand ratios for external stability at the maximum design heights are presented in Table 9. Results of the MSE wall design calculations are attached to this memo. Results of the global stability analyses are summarized in Table 10 and attached to this memo. These are greater than the typical value of 70 percent of the design height due to the steepness of existing slopes below the walls and potential for elevation water levels.

Table 9:- Calculated Capacity-Demand Ratios at Maximum Design Height

MODE OF FAILURE	CRD	
	Static	Seismic
Base Sliding	2.08	1.02
Bearing	4.09	2.13
Overturning	4.22	1.68

Results of the global stability modelling are also attached and are summarized in Table 10. This table also presents recommended minimum reinforcement lengths to meet acceptable performance criteria for global stability for the walls. As previously discussed, the acceptable performance criteria for walls on this project is lower than the AASHTO defined minimums due to site conditions specific to this project. Table 11 presents a summary of recommended reinforcement lengths based on anticipated maximum wall heights at each site.

Table 10: Calculated Global Stability Factors of Safety

SITE	BACKANALYSIS		FS for AASHTO min. RL[1]		RL for FS ≥1.3 in Static Case		Minimum RL for Global Stability
	Static	*Seismic*	*Static*	*Seismic*	*% of H*	*Seismic FS*	*% of H*
4	1.32	0.99	1.28	0.97	95%	0.98	95%
8	1.21	0.91	1.22	0.91	91%	0.96	91%
10	1.28	0.92	1.2	0.89	106%	0.94	106%
13	1.02	0.75	1.22	0.92	114%	0.98	70%
14	1.01	0.83	1.25	0.93	95%	0.96	70%
15	1.03	0.76	1.41	1.04	70%	1.04	70%
16	1.04	0.77	1.2	0.9	94%	0.97	70%

[1] FS = Factor of Safety, RL = Reinforcement Length, H = Wall Height

If stable bedrock is encountered in the wall excavations, the CFLHD Contract Officer (CO), the CFLHD Geotechnical Engineer, and the Wall Designer should be notified immediately to provide guidance on revision of reinforcement lengths. We anticipate that reinforcement lengths can be truncated to reduce or eliminate excavation of bedrock.

Table 11: Recommended Minimum Reinforcement Lengths for MSE Walls

SITE	H MAX.[1] (ft)	RL MIN.[1] (ft)
4	10	11
	8	9.5
	6	8
8	16	16
	14	14
	12	12.5
	10	11
	8	9.5
	6	8
10	16	16
	14	14
	12	12.5
	10	11
	8	9.5
	6	8
13	14	14
	12	12.5
	10	11
	8	9.5
	6	8

SITE	H MAX.[1] (ft)	RL MIN.[1] (ft)
14	18	17.5
	16	16
	14	14
	12	12.5
	10	11
	8	9.5
	6	8
15	10	11
	8	9.5
	6	8
16	16	16
	14	14
	12	12.5
	10	11
	8	9.5
	6	8

[1]RL = Reinforcement Length, H = Wall Height

4.3 Reinforced Soil Slopes

Based on the observed conditions and to comply with the ERFO objectives to restore the roadway to acceptable and safe conditions within budget, a Reinforced Soil Slope (RSS) was analyzed as a potential repair alternative for Sites 3 and 11 during preliminary development of the project design. At these sites, proposed embankment construction will potentially constrict drainage channels. Preliminary analysis of the RSS was conducted using Slide2. Final internal and external stability of the RSS was not completed. At this time, RSS are not anticipated for incorporation into the project. The preliminary analysis performed indicates that RSS are feasible but does not provide full engineering design. If RSS are selected for inclusion in the project, additional design analyses by the CFLHD Geotechnical Engineer will be required.

5.0 RECOMMENDATIONS AND CONSTRUCTION CONSIDERATIONS

Bedrock is likely to be encountered during excavation for the MSE walls. Based on bedrock outcrops observed along the Nacimiento-Fergusson Road, we interpret that the upper foot or more of bedrock are weathered in most locations. Relatively fresh, hard bedrock was observed in isolated cutslopes along the project alignment. Hard bedrock was not observed in the erosion or slide scars. Therefore, relatively fresh, hard, and intact bedrock may be encountered in excavations for the project and is likely to be encountered in excavations where bedrock is exposed in the adjacent cutslopes. A twelve-inch layer of Foundation Fill should be placed between the excavated bedrock and the bottom of wall, as shown in the plans. Some general information on rock rippability and excavation characteristics is attached to this memorandum for informational purposes. Determination of rippability is the responsibility of the contractor.

The contractor should document the location of bedrock encountered during the retaining wall excavation for review by the CFLHD CO, the CFLHD Geotechnical Engineer, and the Wall Designer. If hard, intact bedrock is encountered, revision of the MSE wall design may be required and desirable to limit excavations in rock and minimize required shoring areas. The Contractor should work with CFLHD to document the bedrock locations early in the construction process, so that design revision may be completed in a timely manner. This design revision may include truncation of reinforcements in the lower portion of the MSE wall.

Shoring is anticipated at the retaining wall locations to maintain the required temporary roadway width. Design of shoring and excavation safety is the responsibility of the contractor. As an alternative to shoring, access ramps that allow passenger and emergency response vehicles to pass through the wall excavations may also be considered.

Retaining wall design and construction should conform to the FP-14 and project Special Contract Requirements (SCR), Sections 257 and 255, respectively.

6.0 DISCLAIMERS/LIMITATIONS CLAUSE

Subsurface exploration was not performed as a part of this scope of work. Interpretation of surface and subsurface conditions is based on limited field reconnaissance and surface mapping of soil and rock outcrops. The Recommendations section of this report includes interpretations and recommendations developed by the Government in the process of preparing the design. These interpretations are not intended as a substitute for the personal investigation, independent interpretation, and judgement of the Contractor.

Attachments (4)

A - Lab Testing Results

B - Site Photos

C - Excavation Characteristics of Rocks and Rippability Charts

D - Slope Stability and MSE Wall Design Analyses

Prepared by:

JAMES M ARTHURS Digitally signed by JAMES M ARTHURS Date: 2023.01.04 11:03:12 -07'00'

James Arthurs

Acting Lead Geotechnical Engineer, CFLHD

Reviewed by:

EVAN A GARICH Digitally signed by EVAN A GARICH Date: 2023.01.04 12:01:51 -08'00'

Evan Garich

Geotechnical Engineer, WFLHD

Approved by:

JAMES M ARTHURS Digitally signed by JAMES M ARTHURS Date: 2023.01.04 11:45:09 -07'00'

James Arthurs, Ph.D., P.E.

Acting Lead Geotechnical Engineer, CFLHD

7.0 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO). "AASHTO LRFD Bridge Design Specifications." Ninth Edition, 2020.

California Department of Transportation (CalTrans). (2022). "ARS Online v.2.3.09". <http://dap3.dot.ca.gov/ARS_Online/index.php>

Graymer, R.W., Langenheim, V.E., Roberts, M.A., and McDougall, K. 2014. "Geologic and Geophysical Maps of the Eastern Three-Fourths of the Cambria 30' x 60' Quadrangle, Central California Coast Ranges." 1:100,000. U.S. Geological Survey, Scientific Investigation Map 3287.

Rosenberg, L.I. and Wills, C.J. 2016. "Preliminary Geologic Map of the Point Sur 30' x 60' Quadrangle." 1:100,000. California Geologic Survey.

U.S. Department of Transportation, Federal Highway Administration (FHWA). (2014). "Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects, FP-14." Publication No. FHWA-FLH-14-001.

U.S. Department of Transportation, Federal Highway Administration (FHWA). (2009). "Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes." Publication No. FHWA-NHI-10-024.

U.S. Geological Survey (2022a). "Quaternary Fault and Fold Database of the United States." USGS Earthquake Hazards Program, <http://earthquake.usgs.gov/hazards/qfaults/>

U.S. Geologic Survey (2022b). "U.S. Seismic Design Maps." USGS Earthquake Hazards Program, <http://earthquake.usgs.gov/designmaps/us/application.php>

CA ERFO FS LSPDR 2021-1(1)

Nacimiento-Fergusson Road

A – Lab Results

Central Federal Lands Highway Division Laboratory

An AASHTO and ISO Accredited Laboratory
1 Denver Federal Center, Building 52
Denver, Colorado 80225

U.S. Department of Transportation
Federal Highway Administration

AASHTO ACCREDITED

Report of Soil or Aggregate Tests

Project: California ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Road
Submitted By: James Arthurs
Date Reported: 3/10/2022

Sample Number	Lab Number		22-30-S	22-31-S	22-32-S		
	Hole Number		Not Furnished	Not Furnished	Not Furnished		
	Field Number		Not Furnished	Not Furnished	Not Furnished		
Sample Location	Station or Location		Borrow Area #1	Borrow Area #5	Borrow Area #7		
	Intended Use		Wall Backfill, Embankment Fill				
AASHTO T 11 & T 27 Washed Sieve Analysis % Passing	3"	75.0 mm	100	100	100		
	1 1/2"	37.5 mm	88	90	93		
	1"	25.0 mm	78	85	89		
	3/4"	19.0 mm	71	81	86		
	1/2"	12.5 mm	62	73	81		
	3/8"	9.5 mm	56	68	77		
	#4	4.75 mm	40	52	66		
	#8	2.36 mm					
	#10	2.00 mm	24	33	51		
	#16	1.18 mm	17	22	44		
	#30	600 µm					
	#40	425 µm	8	9	34		
	#50	300 µm					
	#100	150 µm	4	4	21		
	#200	75 µm	1.9	2.4	11		
AASHTO T 255	Moisture, %						
AASHTO T 89 & T 90	Liquid Limit		NV	NV	NV		
	Plasticity Index		NP	NP	NP		
Soil Classification	AASHTO M 145		A-1-a (0)	A-1-a (0)	A-1-b (0)		
	ASTM D 2487		GW	SP	SP-SM		
AASHTO T 190	R - Value						
AASHTO T 288	Min. Resistivity, ohm x cm		8,620	7,960	5,040		
AASHTO T 289	pH		6.8	6.9	7.1		
AASHTO T 99 Method A	Optimum Moisture, %		*6.6				
	Maximum Dry Density, pcf						
AASHTO T 180 Method D	Optimum Moisture, %				**8.6		
	Maximum Dry Density, pcf				**126.1		
AASHTO T 96	LA Abrasion, Grading A, % Loss		75	44	Not Enough Material to Perform		

Distribution:	Num. / Project File
Geotechnical	James Arthurs/ Todd Hansen
Const Ops Engineer	
Project Manager	
Technical Services	Michael Voth

Remarks: * Per Section 204.11(b) the calculated Optimum Moisture Content is reported, compaction requirements are listed in 204.11(a). For informational purposes, the -#4 materials Maximum Dry Density is 122.5 and the Optimum Moisture Content is 11.6. Due to the amount of oversized particles, the corrected AASHTO T 99 Method A Maximum Dry Density is 143.6 pcf and the corrected Optimum Moisture is 4.6%
** Due to the amount of oversized particles, the corrected AASHTO T 180 Method D Maximum Dry Density is 130.2 pcf and the corrected Optimum Moisture is 7.4%.
For both corrected Maximum Dry Densities, an assumed value for the specific gravity of 2.600 has been used for the oversized particles.
Sampling Method: Not Furnished.
Environmental Conditions: Not Furnished.

Reported By:

Patrick K

Patrick Kowing
Laboratory Team Leader

CA ERFO FS LSPDR 2021-1(1)

Nacimiento-Fergusson Road

B - Photos

Site 2

Photo 1: Eroded embankment

Photo 2: Plugged culvert

Site 3

Photo 3: Embankment erosion

Photo 4: Upstream view of drainage

Photo 5: Cut slope above roadway

Site 4

Photo 6: Embankment erosion

Sites 5 and 6

Photo 7: Overall site with debris piled on shoulders, embankment erosion below red vehicle

Photo 8: Debris piles on shoulders and upstream channel, culvert outlet buried under debris

Photo 9: Debris in upstream channel

Photo 10: Embankment failure due to scour and erosion of toe

Site 8

Photo 11: Embankment failure looking up station

Photo 12: Embankment failure looking downstation

Site 10

Photo 13: Embankment failure around culvert

Photo 14: Bedrock in cut slope adjacent to embankment failure

Site 11

Photo 15: Embankment damage

Photo 16: Embankment failure due to scour and erosion in channel

Site 13

Photo 17: Embankment failure

Photo 18: Bedrock in cut slope above failure

Site 14

Photo 19: Embankment failure

Site 15

Photo 20: Embankment failure

Site 16

Photo 21: Embankment failure / erosion

Photo 22: Culvert adjacent to embankment failure

Potential Borrow Areas

Photo 23: Borrow Area 1

Photo 24: Borrow Area 2

Photo 25: Borrow Area 6

Photo 26: Borrow Area 7

CA ERFO FS LSPDR 2021-1(1)

Nacimiento-Fergusson Road

C – Excavation Characteristics of Rocks

And Rippability Charts

Table C.1: Rock Hardness and Excavation Characteristics[1]

Rock Hardness Description	Identification Criteria	Unconfined Compressive Strength		Seismic Compression (P-Wave) Velocity		Excavation Characteristics
		MPa	psi	m/s	f/s	
Very Soft Rock	Material crumbles under firm blows with sharp end of geological pick; can be peeled with a knife; too hard to cut a triaxial sample by hand. SPT will refuse. Pieces up to 3-c, thick can be broken by finger pressure.	1.7-3.0	246-435	450-1,200	1,475-3,935	Easy Ripping
Soft Rock	Can just be scraped with a knife; indentations 1-mm to 3-mm show in specimen with firm blows of the pick point; has dull sound under hammer.	3.0-10.0	435-1,450	1,200-1,500	3,935-4,920	Hard Ripping
Hard Rock	Cannot be scraped with a knife; hand specimen can be broken with a pick with a single firm blow; rock rings under hammer.	10.0-20.0	1,450-2,900	1,500-1,850	4,920-6,070	Very Hard Ripping
Very Hard Rock	Hand specimen breaks with a pick after more than one blow; rock rings under hammer.	20.0-70.0	2,900-10,150	1,850-2,150	6,070-7,050	Extremely Hard Ripping or Blasting
Extremely Hard Rock	Specimen require many blows with geological pick to break through intact material; rock rings under hammer.	> 70.0	> 10,150	> 2,150	>7,050	Blasting

[1]Table from Weaver (1975).

Table C.2: Excavation Characteristics of Rock[2]

Classification Elements	Class I **Very hard ripping to blasting**	Class II **Hard ripping**	Class III **Easy ripping**
	Rock material requires drilling and explosives or impact procedures for excavation may classify as rock excavation (NRCS Construction Spec. 21). **Must fulfill all conditions below:**	Rock material requires ripping techniques for excavation may classify as rock excavation (NRCS Construction Spec. 21). **Must fulfill all conditions below:**	Rock material can be excavated as common material by earth-moving or ripping equipment may classify as common excavation (NRCS Construction Spec. 21). **Must fulfill all conditions below:**
Headcut erodibility index, k_h (NEH628.52)	$k_h \geq 100$	$10 < k_h < 100$	$k_h \leq 10$
Seismic velocity, approximate (ASTM D5777 and Caterpillar Handbook of Ripping, 1997)	> 2,450 m/s (> 8,000 ft/s)	2,150-2,450 m/s (7,000-8,000 ft/s)	< 2,150 m/s (< 7,000 ft/s)
Minimum equipment size (flywheel power) required to excavate rock. All machines assumed to be heavy-duty, track-type backhoes or tractors equipped with a single tine, rear-mounted ripper.	260 kW (350 hp), for $k_h < 1,000$ 375 kW (500 hp), for $k_h < 10,000$ Blasting, for $k_h > 10,000$	185 kW (250 hp)	110 kW (150 hp)

[1]The classification is a general guide and does not prescribe the actual contract payment method to be used, nor supersedes NRCS contract documents. The classification is for engineering design purposes only.

[2]Table from USDA (2012).

USE OF SEISMIC VELOCITY CHARTS[1]

The charts of ripper performance estimated by seismic wave velocities have been developed from field tests conducted in a variety of materials. Considering the extreme variations among materials and even among rocks of a specific classification, the charts must be recognized as being at best only one indicator of rippability.

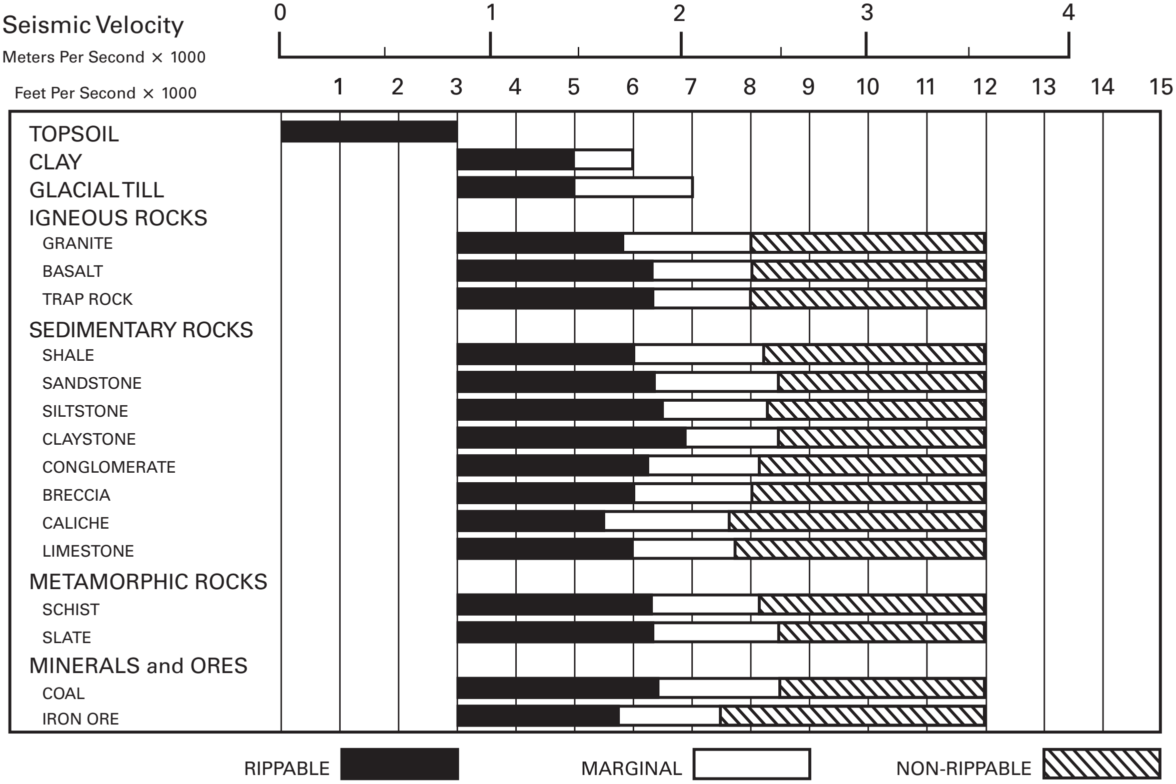
Accordingly, consider the following precautions when evaluating the feasibility of ripping a given formation:

- Tooth penetration is often the key to ripping success, regardless of seismic velocity. This is particularly true in homogeneous materials such as mudstones and claystones and the fine-grained caliches. It is also true in tightly cemented formations such as conglomerates, some glacial tills and caliches containing rock fragments.
- Low seismic velocities of sedimentaries can indicate probable rippability. However, if the fractures and bedding joints do not allow tooth penetration, the material may not be ripped effectively.
- Pre-blasting or “popping” may induce sufficient fracturing to permit tooth entry, particularly in the caliches, conglomerates and some other rocks; but the economics should be checked carefully when considering popping in the higher grades of sandstones, limestones and granites.

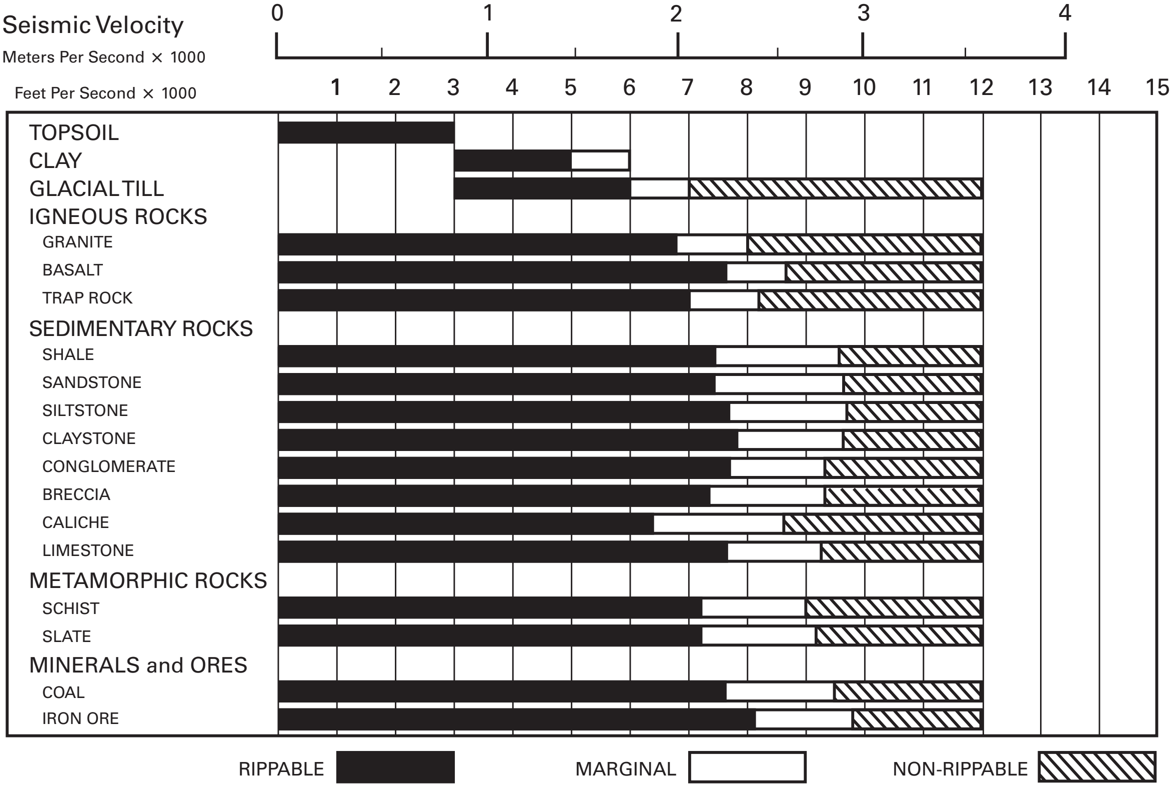
Ripping is still more art than science, and much will depend on operator skill and experience. Ripping for scraper loading may call for different techniques than if the same material is to be dozed away. Cross-ripping requires a change in approach. The number of shanks used, length and depth of shank, tooth angle, direction, throttle position all must be adjusted according to field conditions. Ripping success may well depend on the operator finding the proper combination for those conditions.

[1]Text and the following tables from Hawthorne Cat (2018).

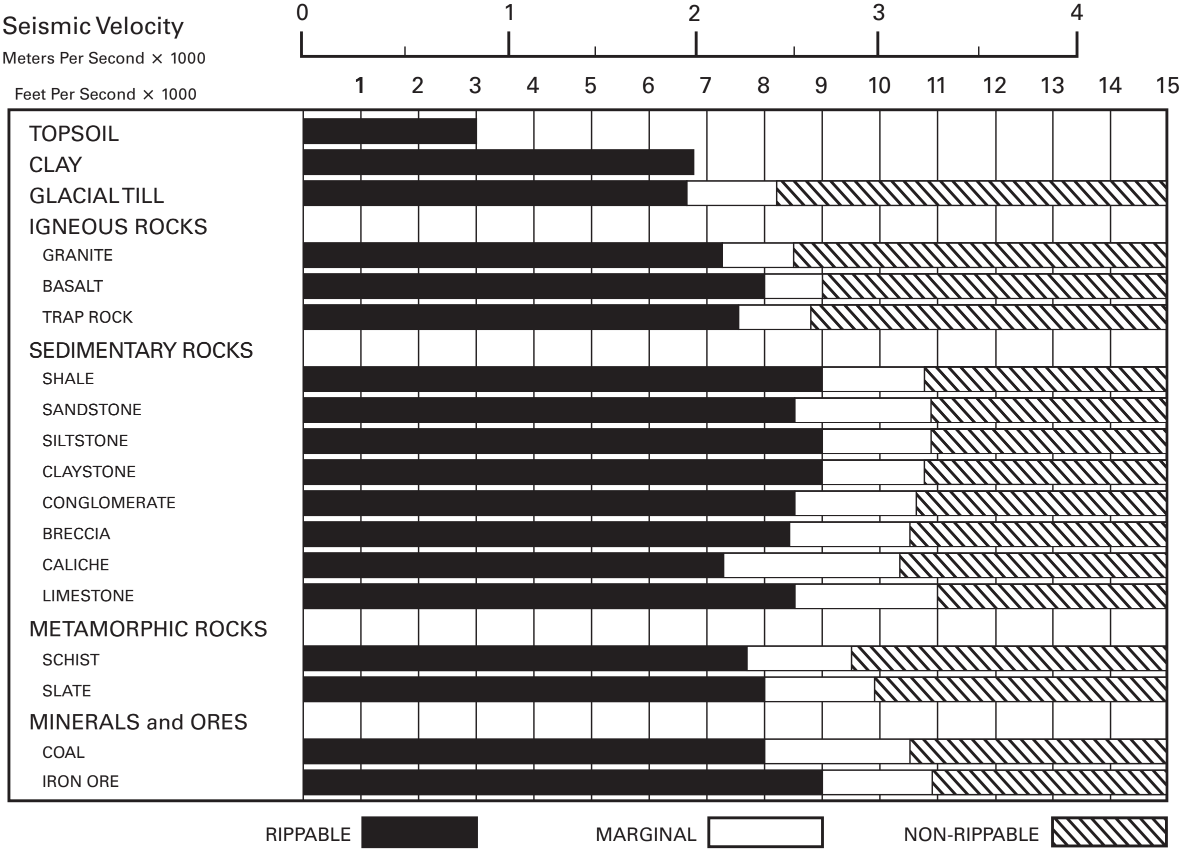
D8R/D8T
- **Multi- or Single Shank No. 8 Ripper**
- **Estimated by Seismic Wave Velocities**



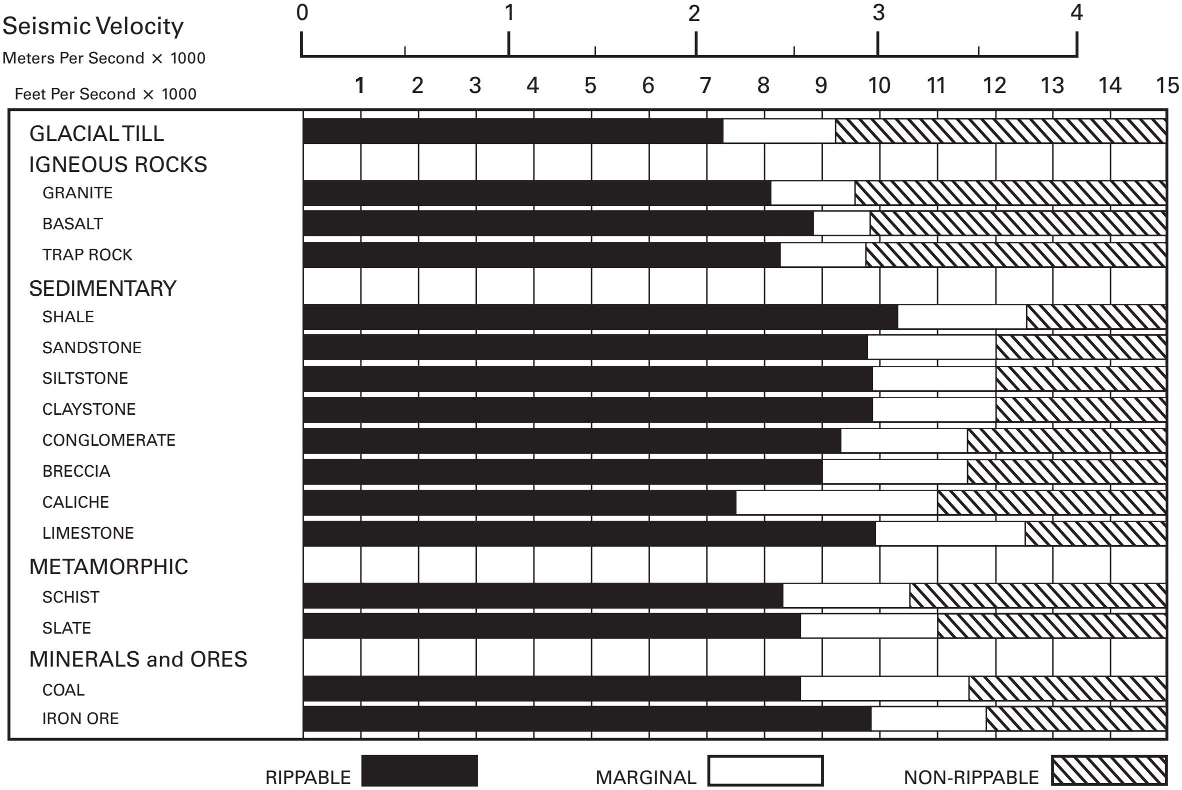
D9R/D9T
● Multi- or Single Shank No. 9 Ripper
● Estimated by Seismic Wave Velocities



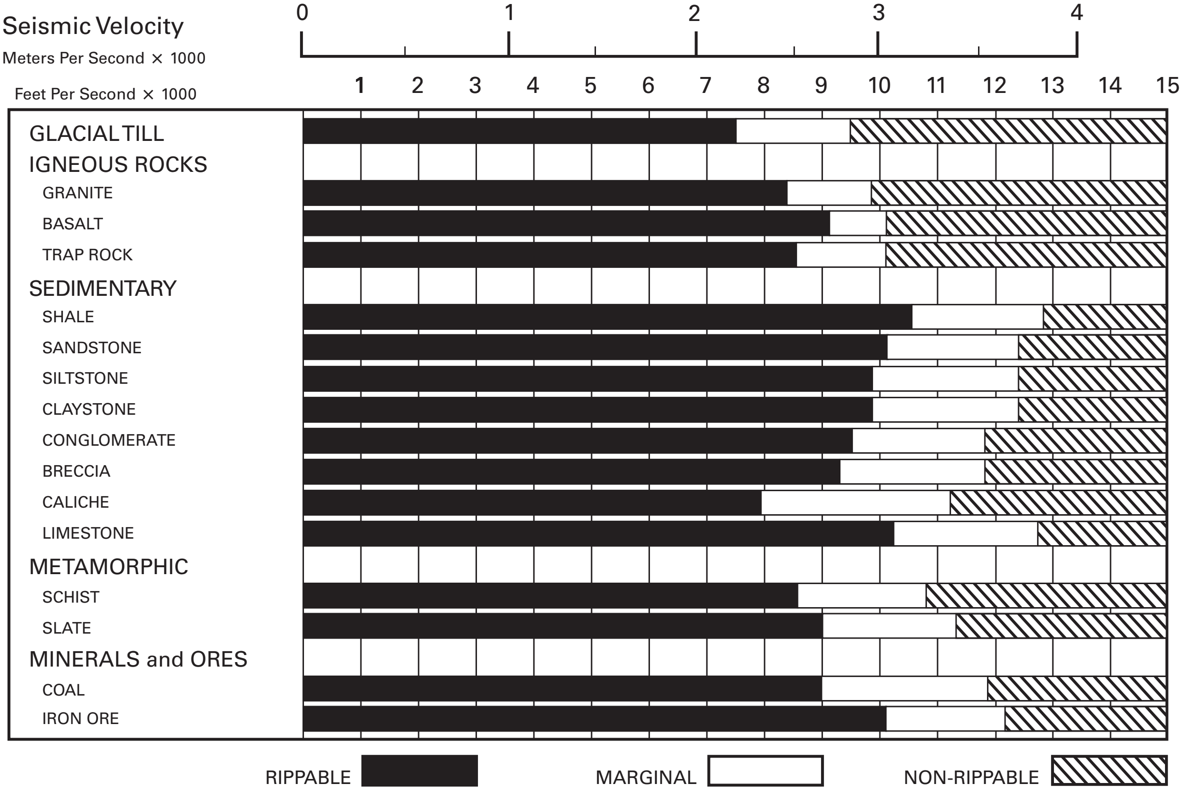
D10T2
- **Multi- or Single Shank No. 10 Ripper**
- **Estimated by Seismic Wave Velocities**



D11T
● Multi- or Single Shank No. 11 Ripper
● Estimated by Seismic Wave Velocities



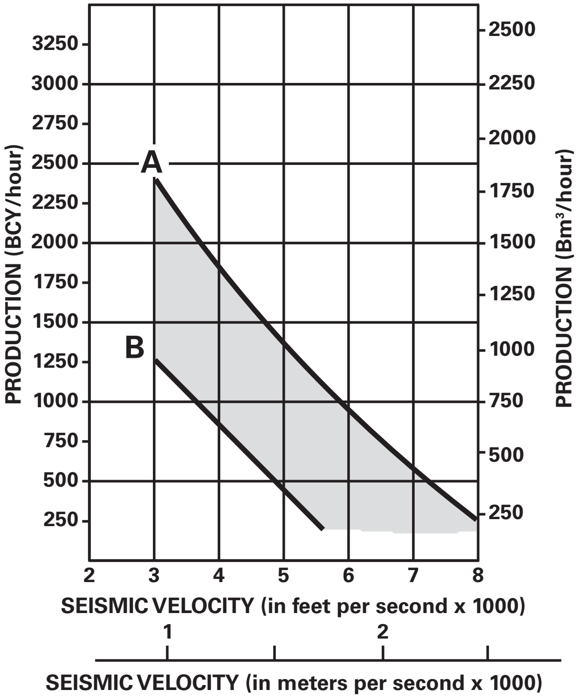
D11T CD
- **Single Shank No. 11 Ripper**
- **Estimated by Seismic Wave Velocities**



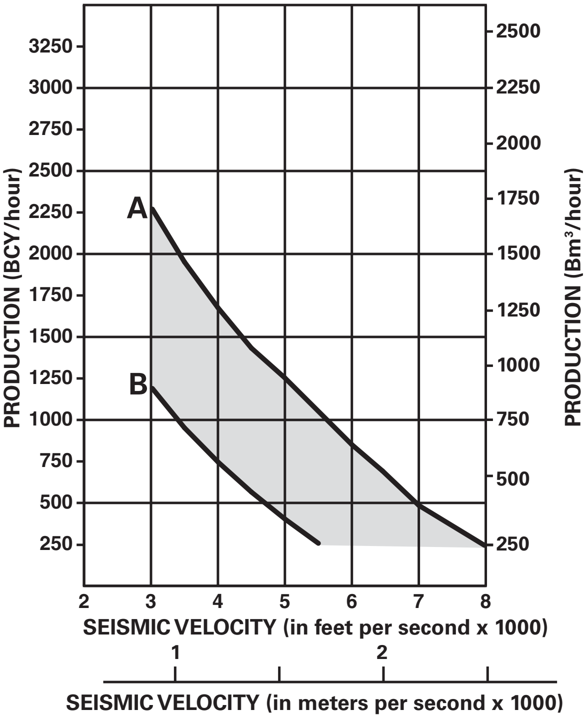
CONSIDERATIONS FOR USING PRODUCTION ESTIMATED GRAPHS:

- Machine rips full-time — no dozing.
- Power shift tractors with single shank rippers.
- 100% efficiency (60 min hour).
- Charts are for all classes of material.
- In igneous rock with seismic velocity of 8000 fps (2450 mps) or higher for the D11T, and 6000 fps (1830 mps) or higher for the D10T2, D9R/D9T and D8R/D8T, the production figures shown should be reduced by 25%.
- Upper limit of charts reflect ripping under ideal conditions only. If conditions such as thick lamination, vertical lamination or any factor which would adversely affect production are present, the lower limit should be used.

D9R/D9T WITH SINGLE SHANK

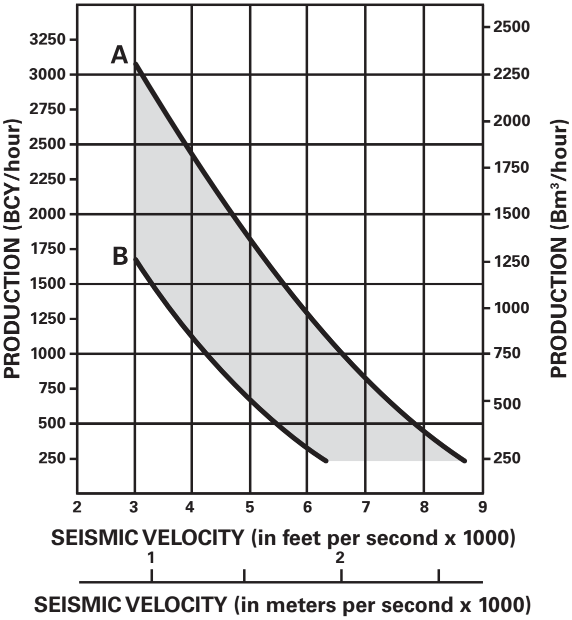


D8R/D8T WITH SINGLE SHANK

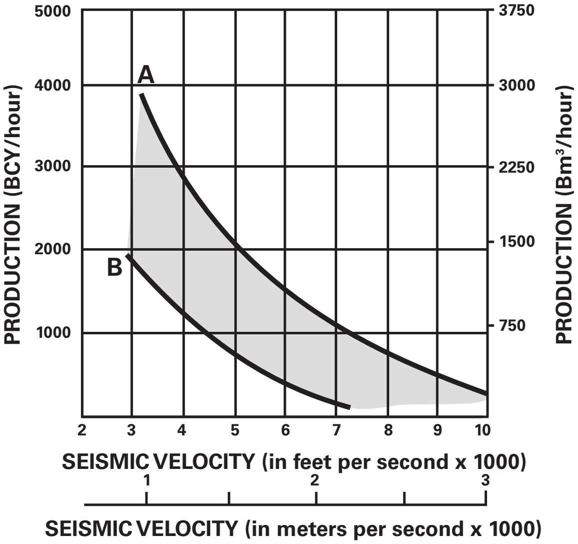


KEY
A — IDEAL
B — ADVERSE

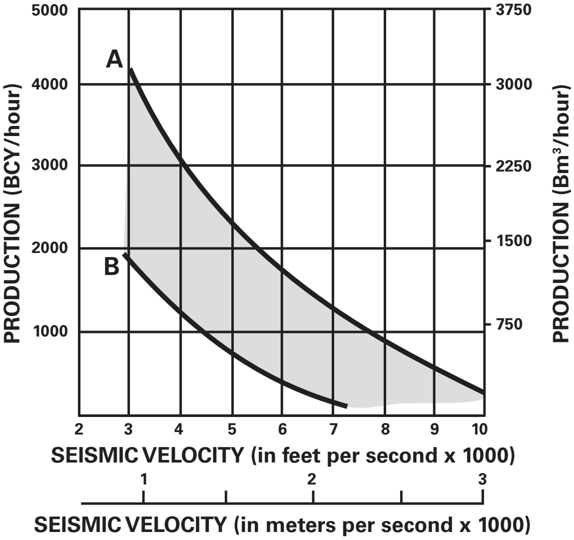
D10T2 WITH SINGLE SHANK



D11T WITH SINGLE SHANK



D11T CD WITH SINGLE SHANK



KEY
A — IDEAL
B — ADVERSE

CA ERFO FS LSPDR 2021-1(1)

Nacimiento-Fergusson Road

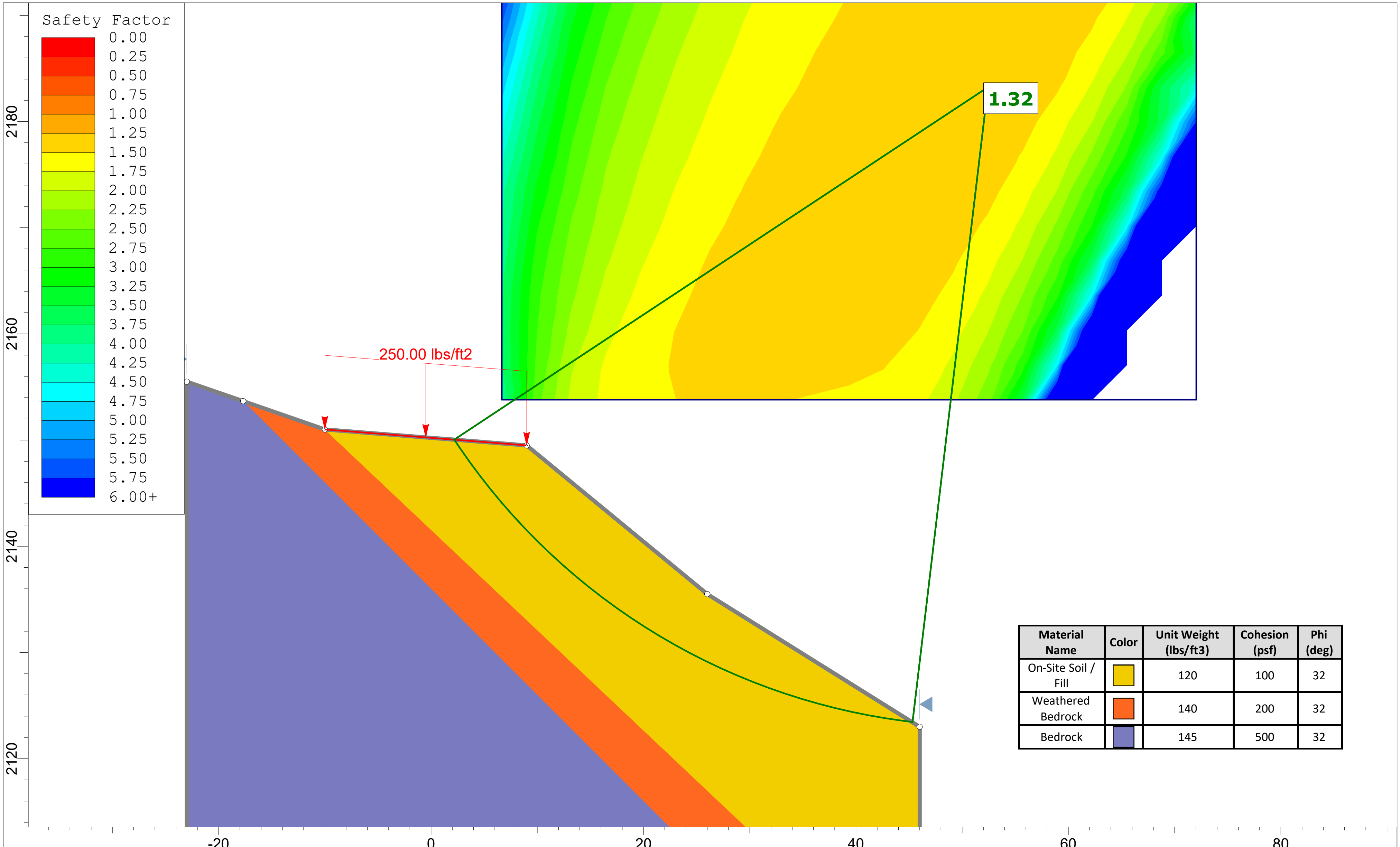
D - Calculations

Prepared by: James Arthurs **Date: 8/17/22**

Checked by: Evan Garich **Date: 9/7/22**

Global Stability (Slide2)

Site 4

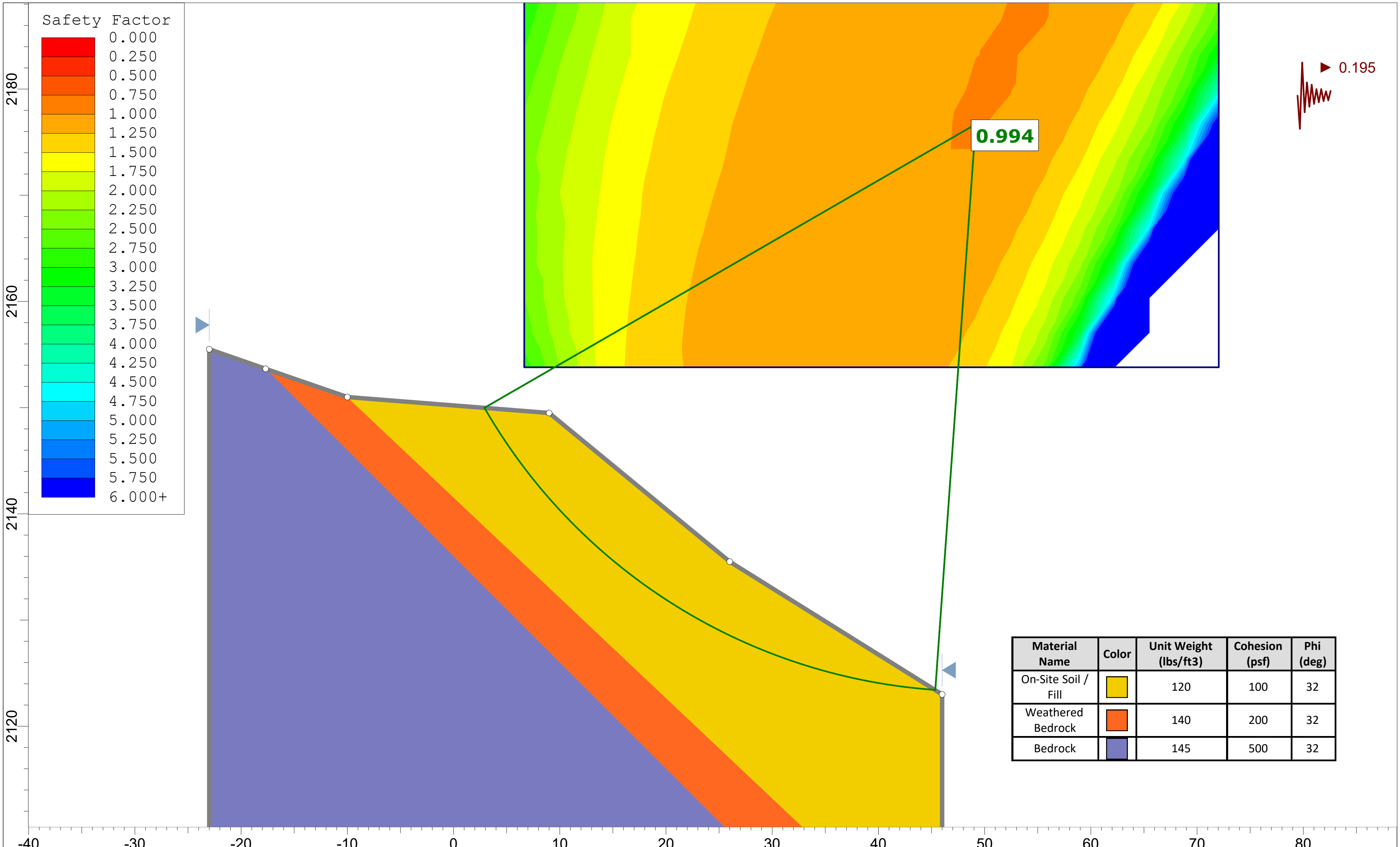


Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	32
Weathered Bedrock		140	200	32
Bedrock		145	500	32

U.S. Department of Transportation
Federal Highway Administration

SLIDEINTERPRET 9.019

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	Backanalysis	*Scenario*	Static
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/9/2022, 3:00:25 PM	*File Name*	Site 4.slmd



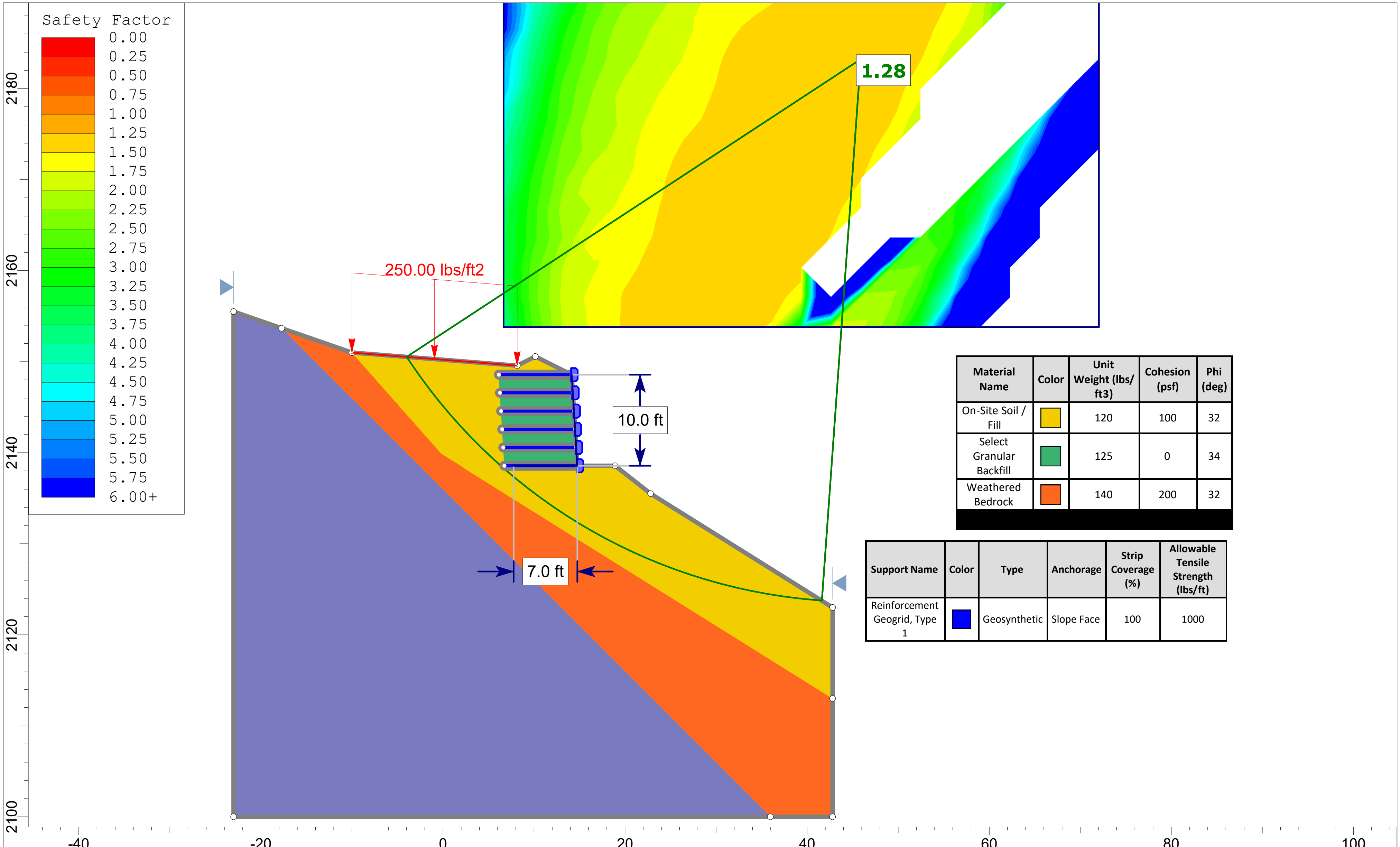
Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	32
Weathered Bedrock		140	200	32
Bedrock		145	500	32

U.S. Department of Transportation
Federal Highway Administration

SLIDEINTERPRET 9.019

Project
CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd

Group Backanalysis	*Scenario* Seismic
Drawn By JMA	*Company* FHWA-CFL
Date 8/9/2022, 3:00:25 PM	*File Name* Site 4.slmd



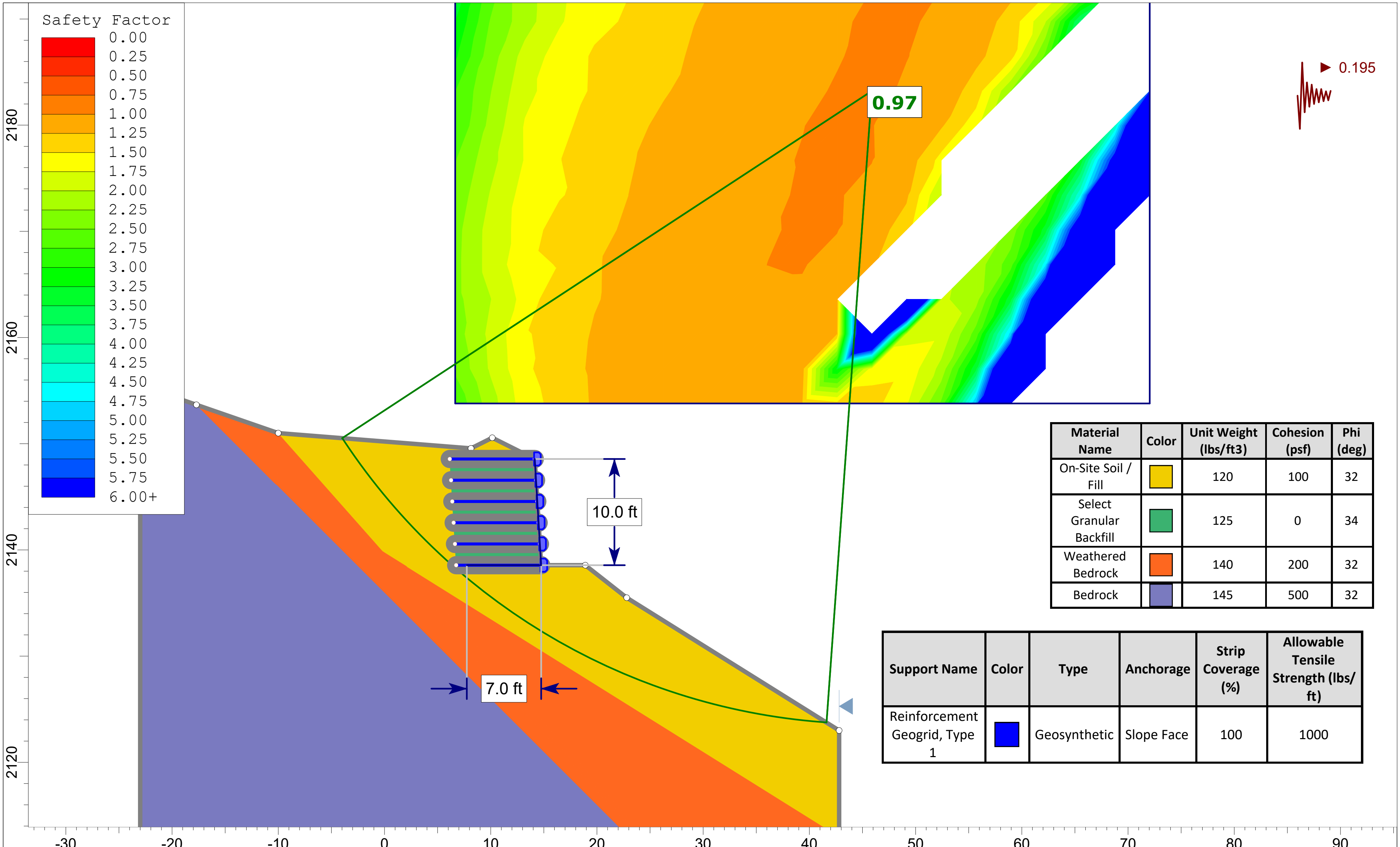
Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	32
Select Granular Backfill		125	0	34
Weathered Bedrock		140	200	32

Support Name	Color	Type	Anchorage	Strip Coverage (%)	Allowable Tensile Strength (lbs/ft)
Reinforcement Geogrid, Type 1		Geosynthetic	Slope Face	100	1000

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	MSE Walls - RL=8'	*Scenario*	Static
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/9/2022, 3:00:25 PM	*File Name*	Site 4.slmd

U.S. Department of Transportation Federal Highway Administration

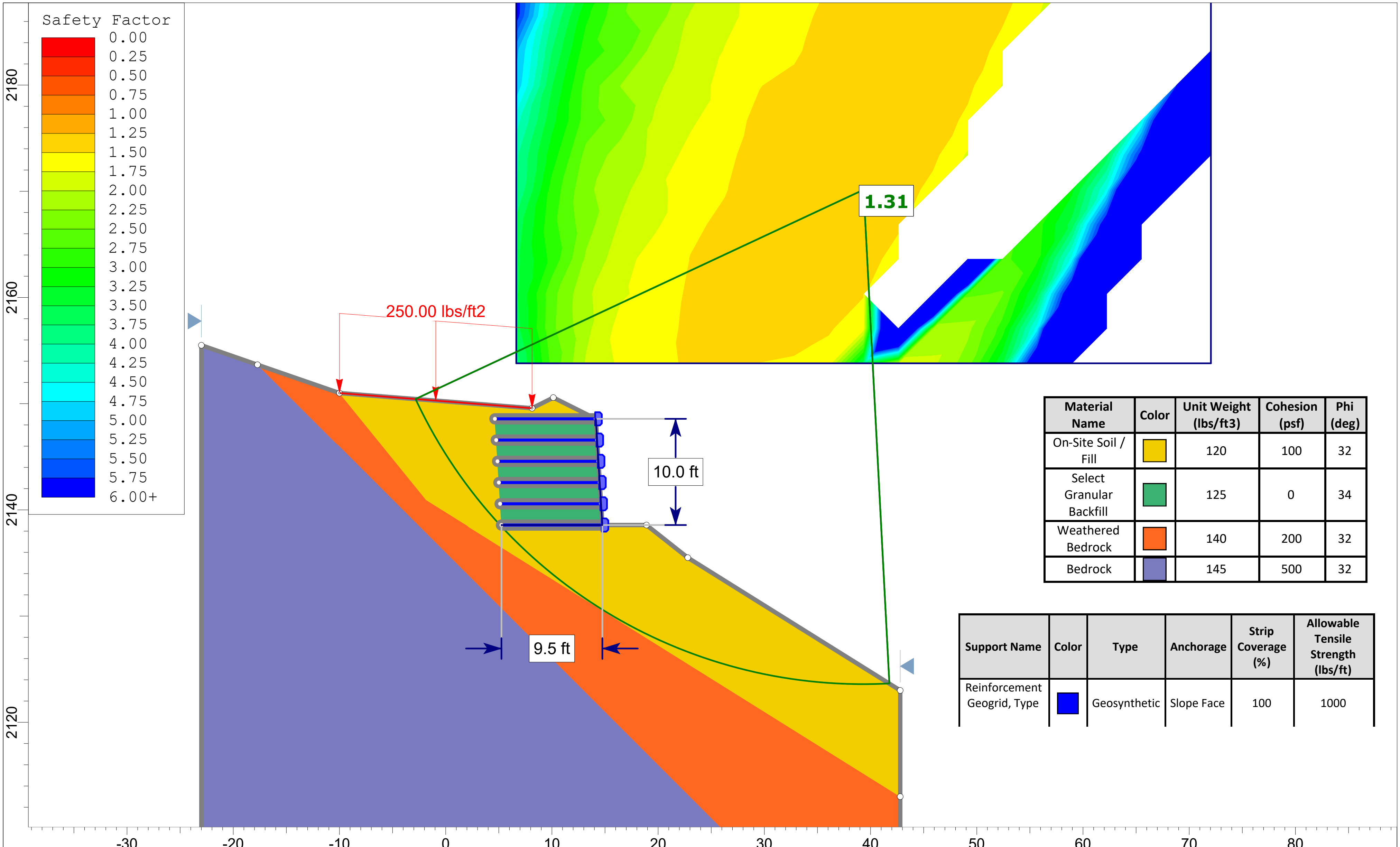
SLIDEINTERPRET 9.019



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	32
Select Granular Backfill		125	0	34
Weathered Bedrock		140	200	32
Bedrock		145	500	32

Support Name	Color	Type	Anchorage	Strip Coverage (%)	Allowable Tensile Strength (lbs/ft)
Reinforcement Geogrid, Type 1		Geosynthetic	Slope Face	100	1000

U.S. Department of Transportation Federal Highway Administration	*Project* CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
	Group MSE Walls - RL=8'	*Scenario* Seismic	
	Drawn By JMA	*Company* FHWA-CFL	
SLIDEINTERPRET 9.019	*Date* 8/9/2022, 3:00:25 PM	*File Name* Site 4.slmd	



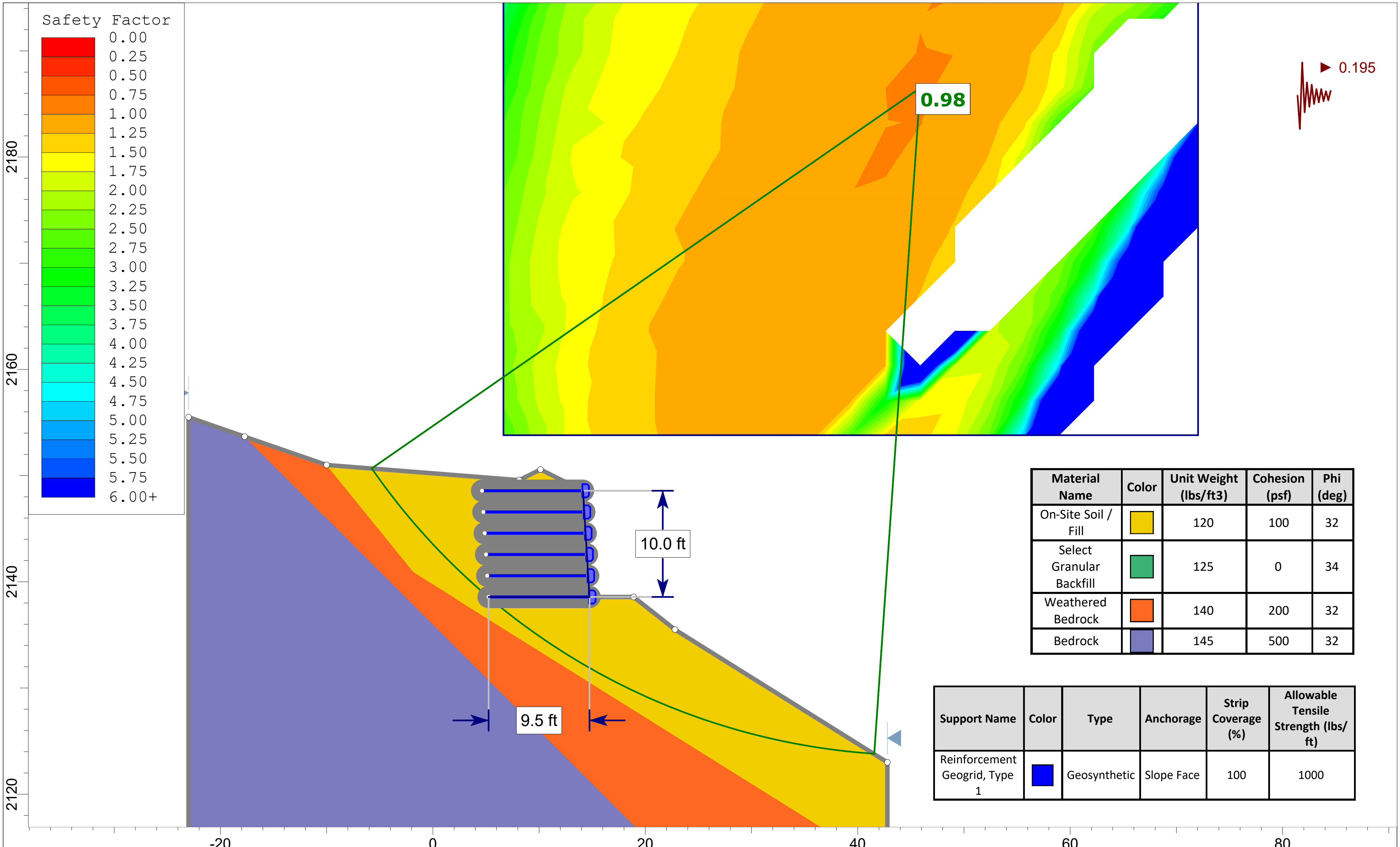
Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	32
Select Granular Backfill		125	0	34
Weathered Bedrock		140	200	32
Bedrock		145	500	32

Support Name	Color	Type	Anchorage	Strip Coverage (%)	Allowable Tensile Strength (lbs/ft)
Reinforcement Geogrid, Type		Geosynthetic	Slope Face	100	1000

U.S. Department of Transportation Federal Highway Administration

SLIDEINTERPRET 9.019

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	MSE Wall - FS=1.3	*Scenario*	Static
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/9/2022, 3:00:25 PM	*File Name*	Site 4.slmd



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	32
Select Granular Backfill		125	0	34
Weathered Bedrock		140	200	32
Bedrock		145	500	32

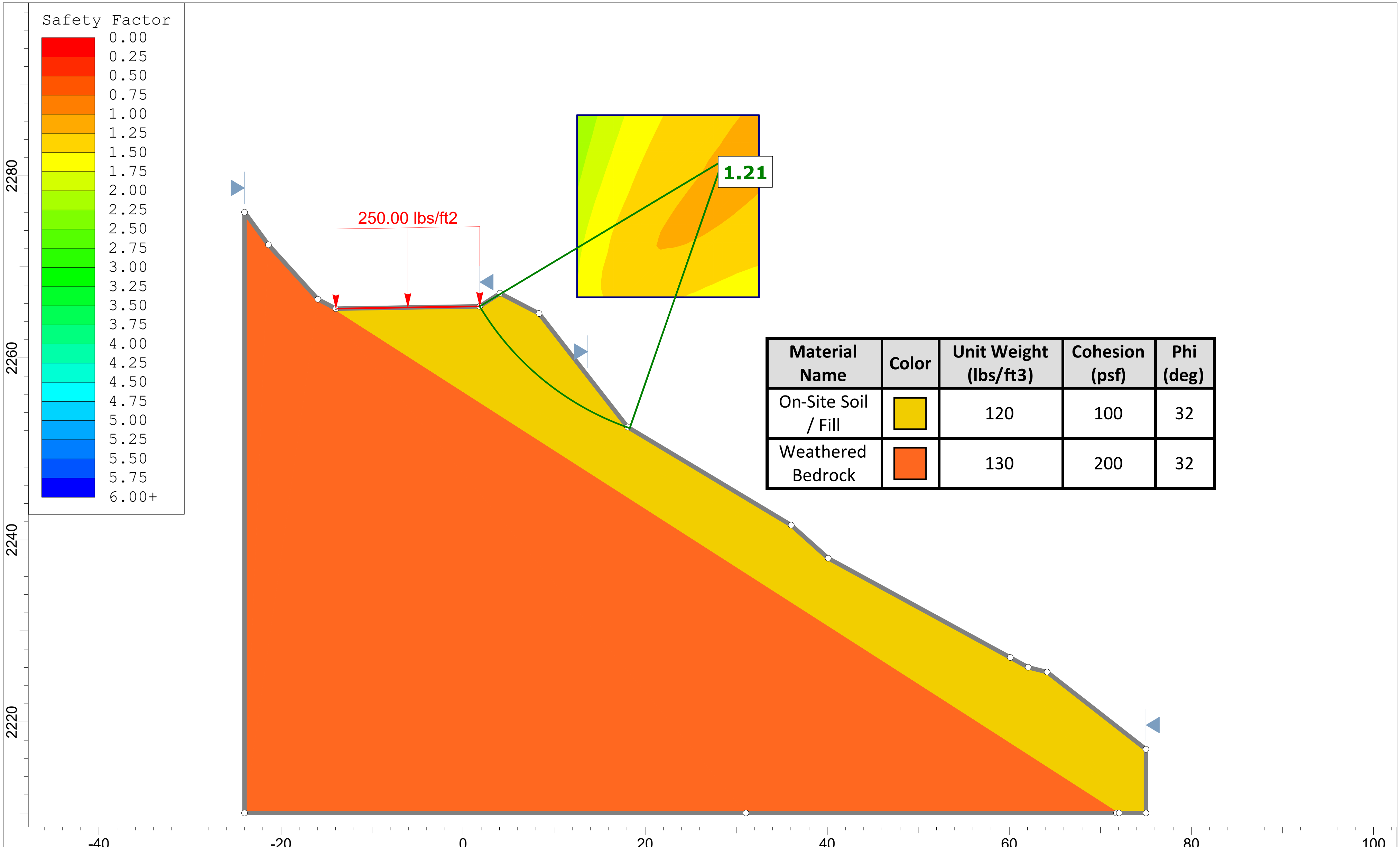
Support Name	Color	Type	Anchorage	Strip Coverage (%)	Allowable Tensile Strength (lbs/ft)
Reinforcement Geogrid, Type 1		Geosynthetic	Slope Face	100	1000

U.S. Department of Transportation Federal Highway Administration

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	MSE Wall - FS=1.3	*Scenario*	Seismic
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/9/2022, 3:00:25 PM	*File Name*	Site 4.slmd

SLIDEINTERPRET 9.019

Site 8

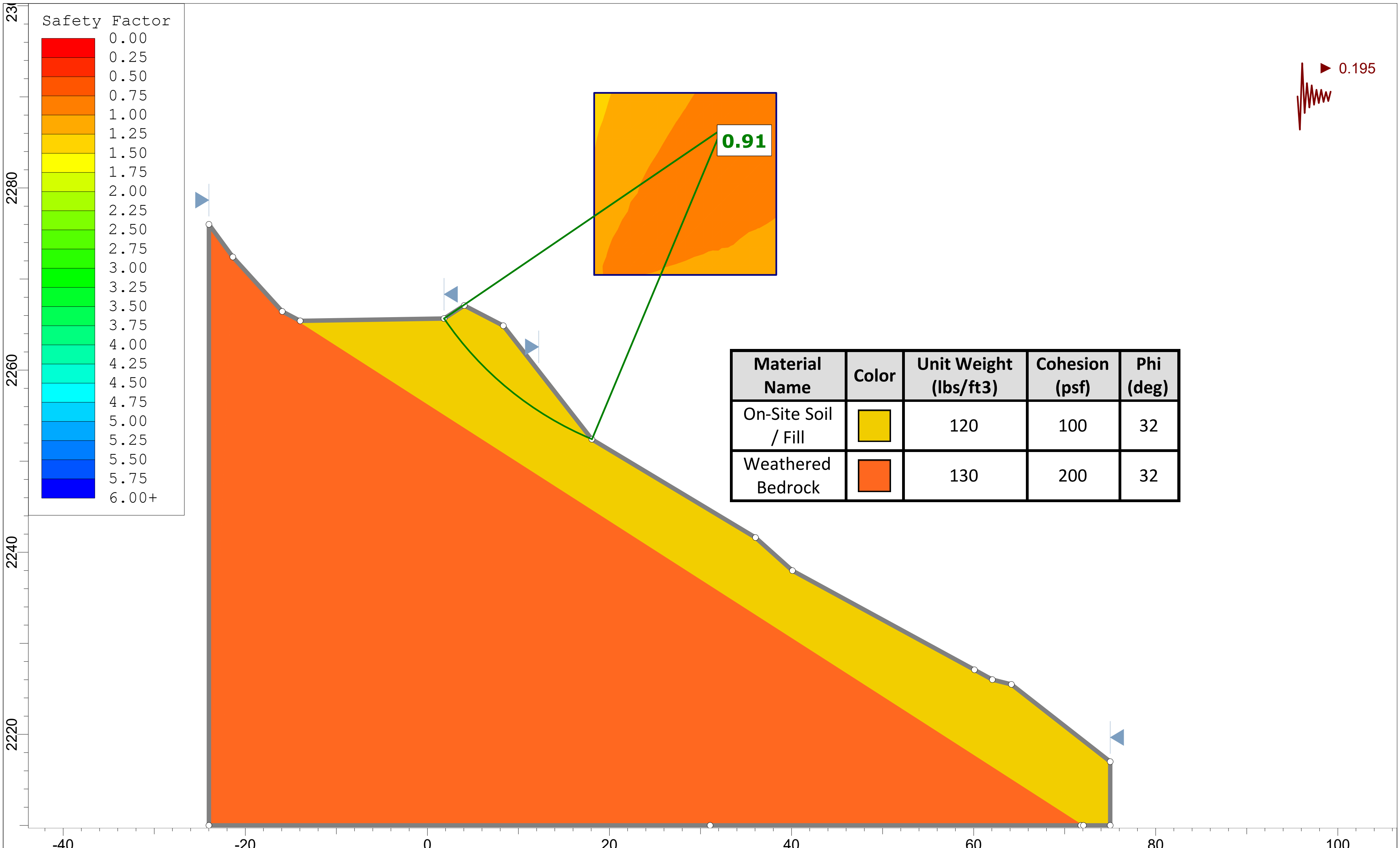


Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	32
Weathered Bedrock		130	200	32

U.S. Department of Transportation
Federal Highway Administration

SLIDEINTERPRET 9.019

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	Backanalysis	*Scenario*	Static
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 8.slmd

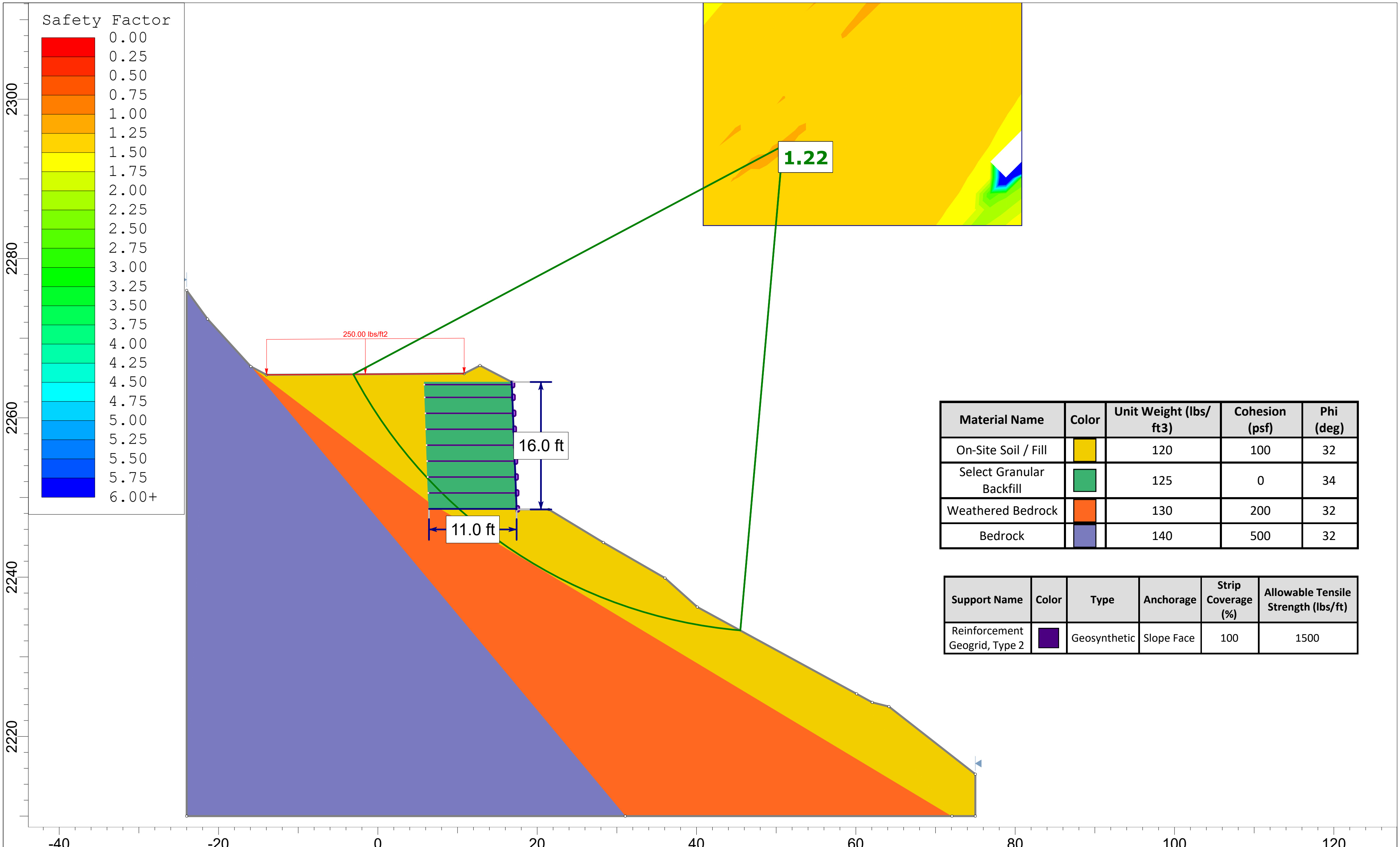


Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	32
Weathered Bedrock		130	200	32

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	Backanalysis	*Scenario*	Seismic
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 8.slmd

U.S. Department of Transportation Federal Highway Administration

SLIDEINTERPRET 9.019



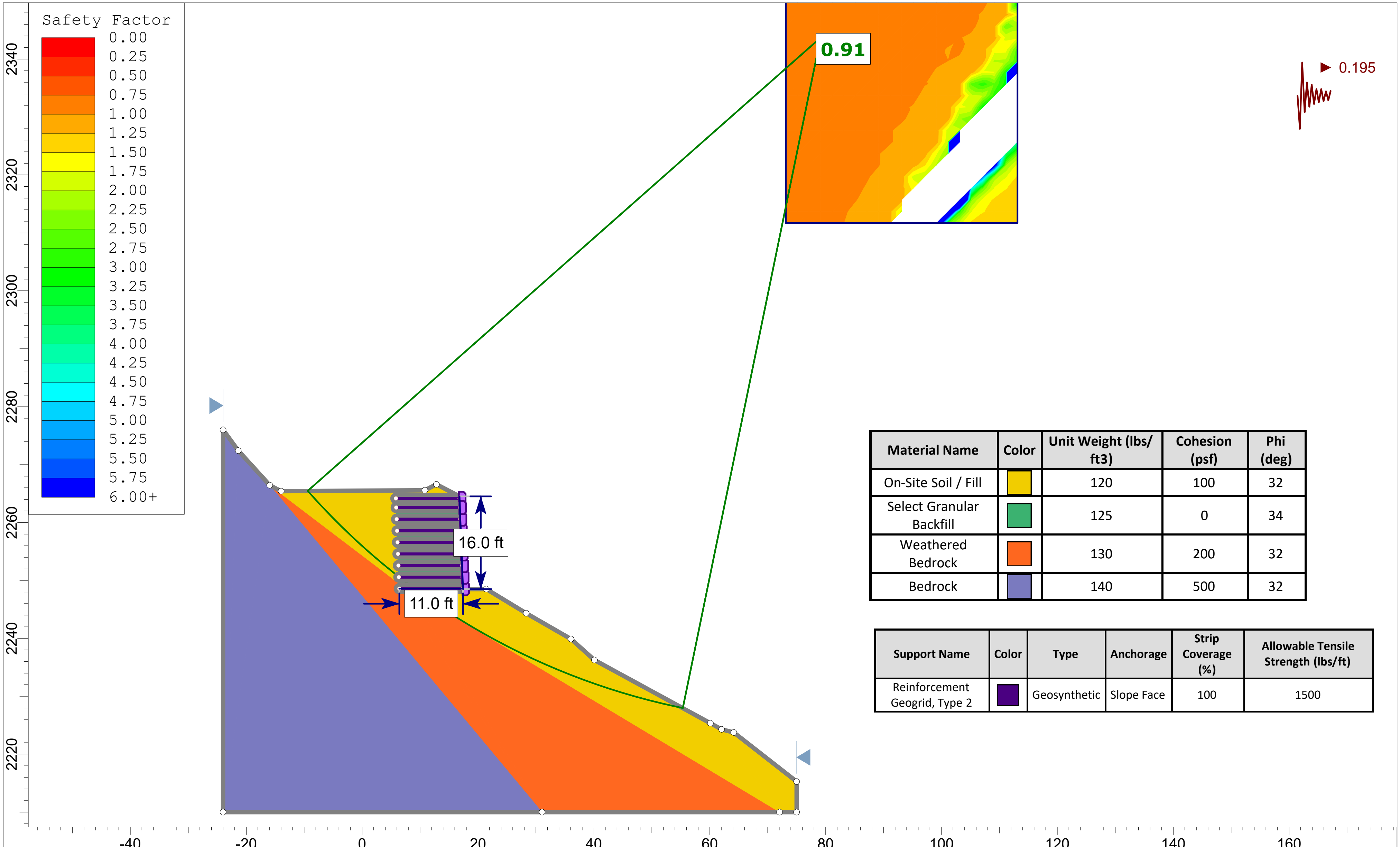
Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	32
Select Granular Backfill		125	0	34
Weathered Bedrock		130	200	32
Bedrock		140	500	32

Support Name	Color	Type	Anchorage	Strip Coverage (%)	Allowable Tensile Strength (lbs/ft)
Reinforcement Geogrid, Type 2		Geosynthetic	Slope Face	100	1500

U.S. Department of Transportation Federal Highway Administration

SLIDEINTERPRET 9.019

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	MSE Wall - RL=70%	*Scenario*	Static
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 8.slmd



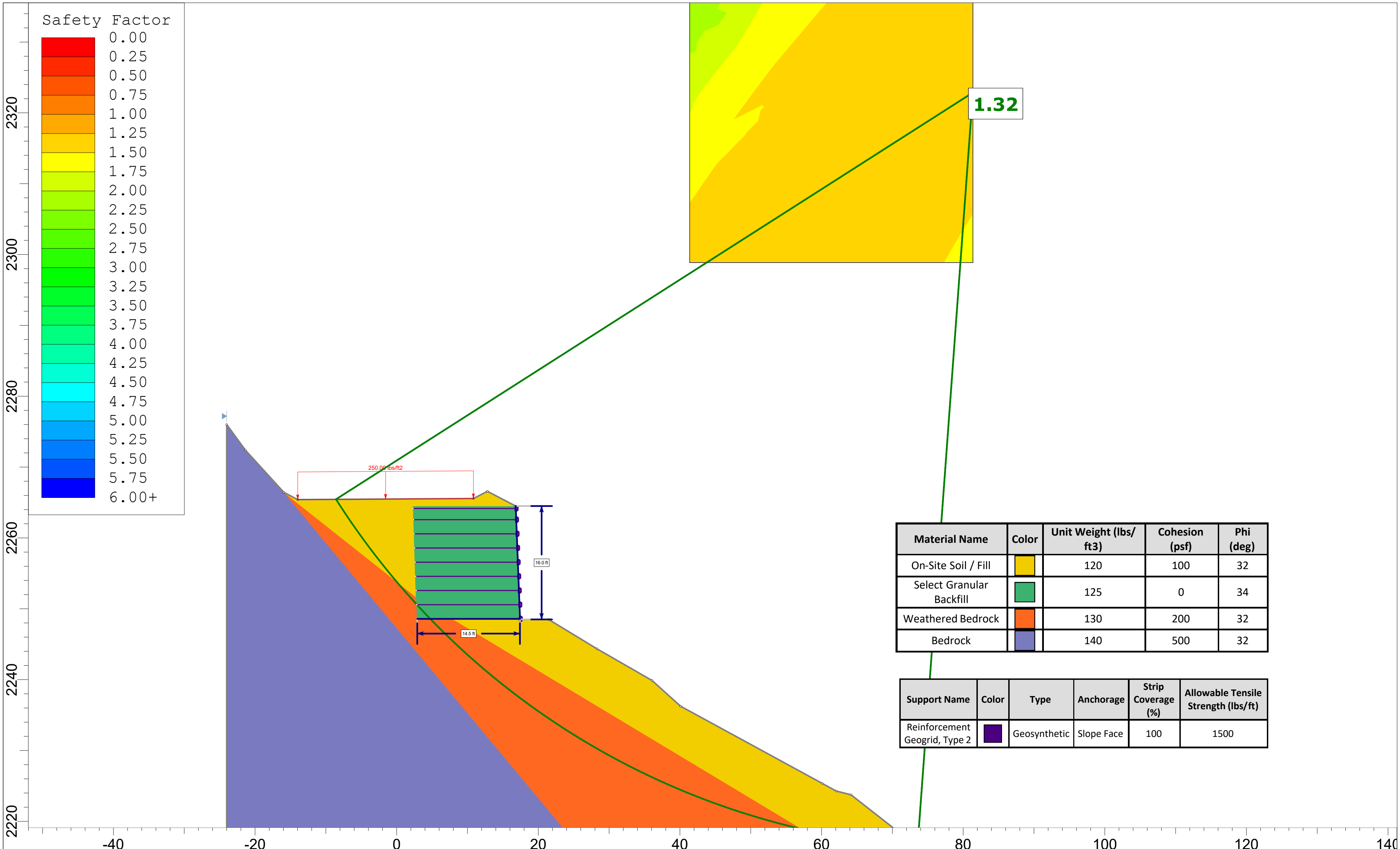
Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	32
Select Granular Backfill		125	0	34
Weathered Bedrock		130	200	32
Bedrock		140	500	32

Support Name	Color	Type	Anchorage	Strip Coverage (%)	Allowable Tensile Strength (lbs/ft)
Reinforcement Geogrid, Type 2		Geosynthetic	Slope Face	100	1500

U.S. Department of Transportation Federal Highway Administration

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	MSE Wall - RL=70%	*Scenario*	Seismic
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 8.slmd

SLIDEINTERPRET 9.019



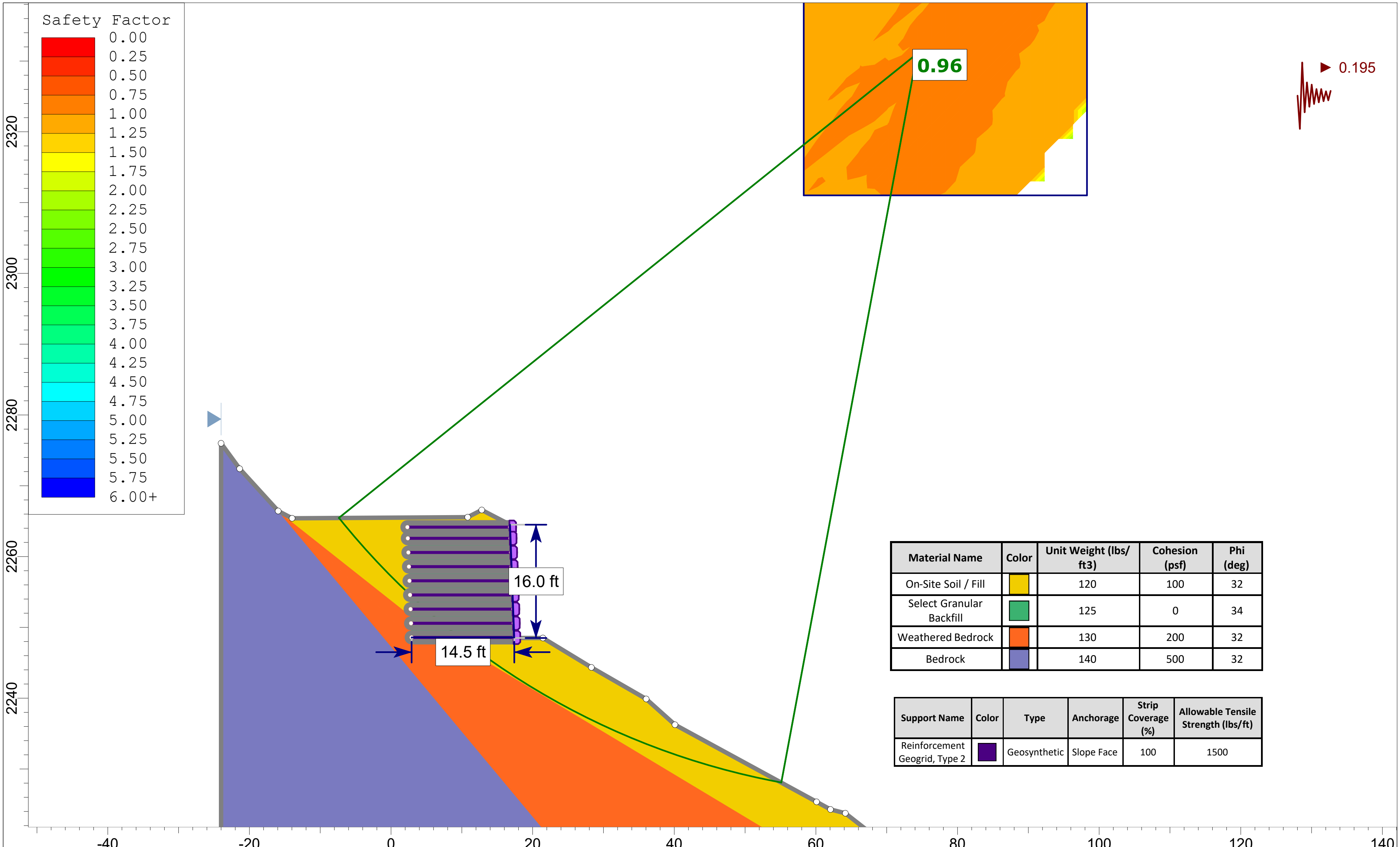
Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	32
Select Granular Backfill		125	0	34
Weathered Bedrock		130	200	32
Bedrock		140	500	32

Support Name	Color	Type	Anchorage	Strip Coverage (%)	Allowable Tensile Strength (lbs/ft)
Reinforcement Geogrid, Type 2		Geosynthetic	Slope Face	100	1500

U.S. Department of Transportation Federal Highway Administration

SLIDEINTERPRET 9.019

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	MSE Wall - FS=1.3	*Scenario*	Static
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 8.slmd



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	32
Select Granular Backfill		125	0	34
Weathered Bedrock		130	200	32
Bedrock		140	500	32

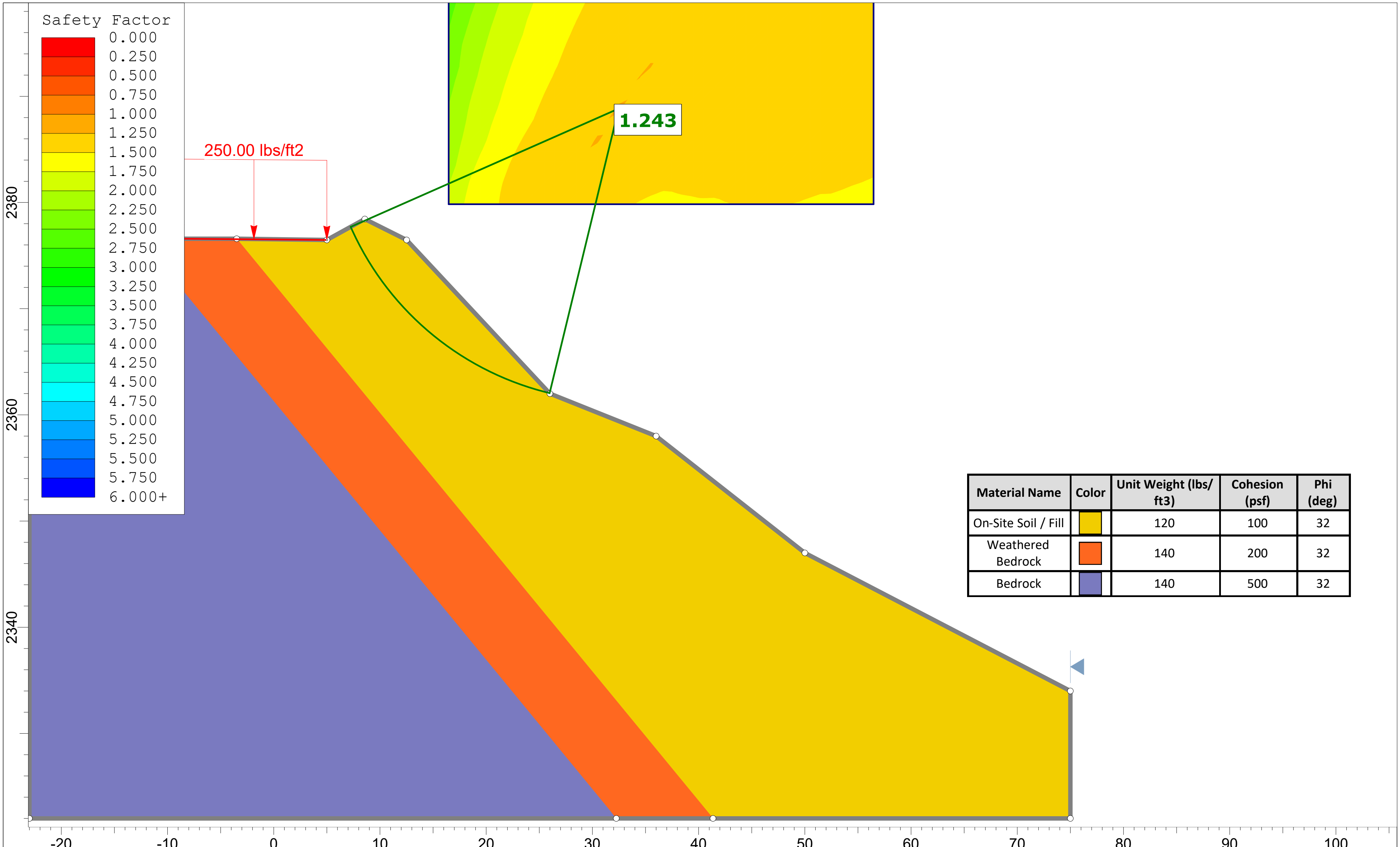
Support Name	Color	Type	Anchorage	Strip Coverage (%)	Allowable Tensile Strength (lbs/ft)
Reinforcement Geogrid, Type 2		Geosynthetic	Slope Face	100	1500

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	MSE Wall - FS=1.3	*Scenario*	Seismic
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 8.slmd

U.S. Department of Transportation Federal Highway Administration

SLIDEINTERPRET 9.019

Site 10

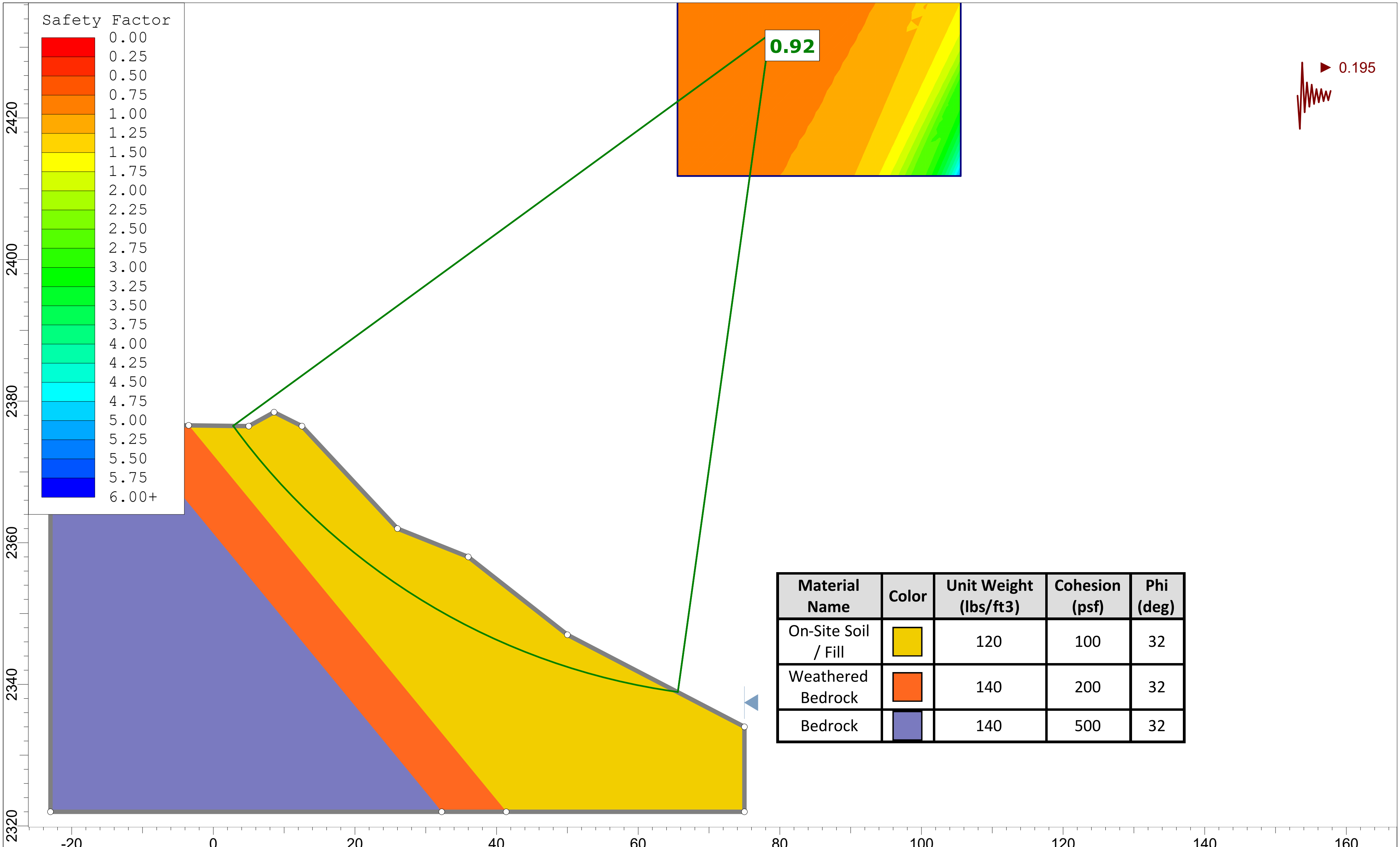


Material Name	Color	Unit Weight (lbs/ ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	32
Weathered Bedrock		140	200	32
Bedrock		140	500	32

U.S. Department of Transportation Federal Highway Administration

SLIDEINTERPRET 9.019

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	Backanalysis	*Scenario*	Static
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 10.slmd

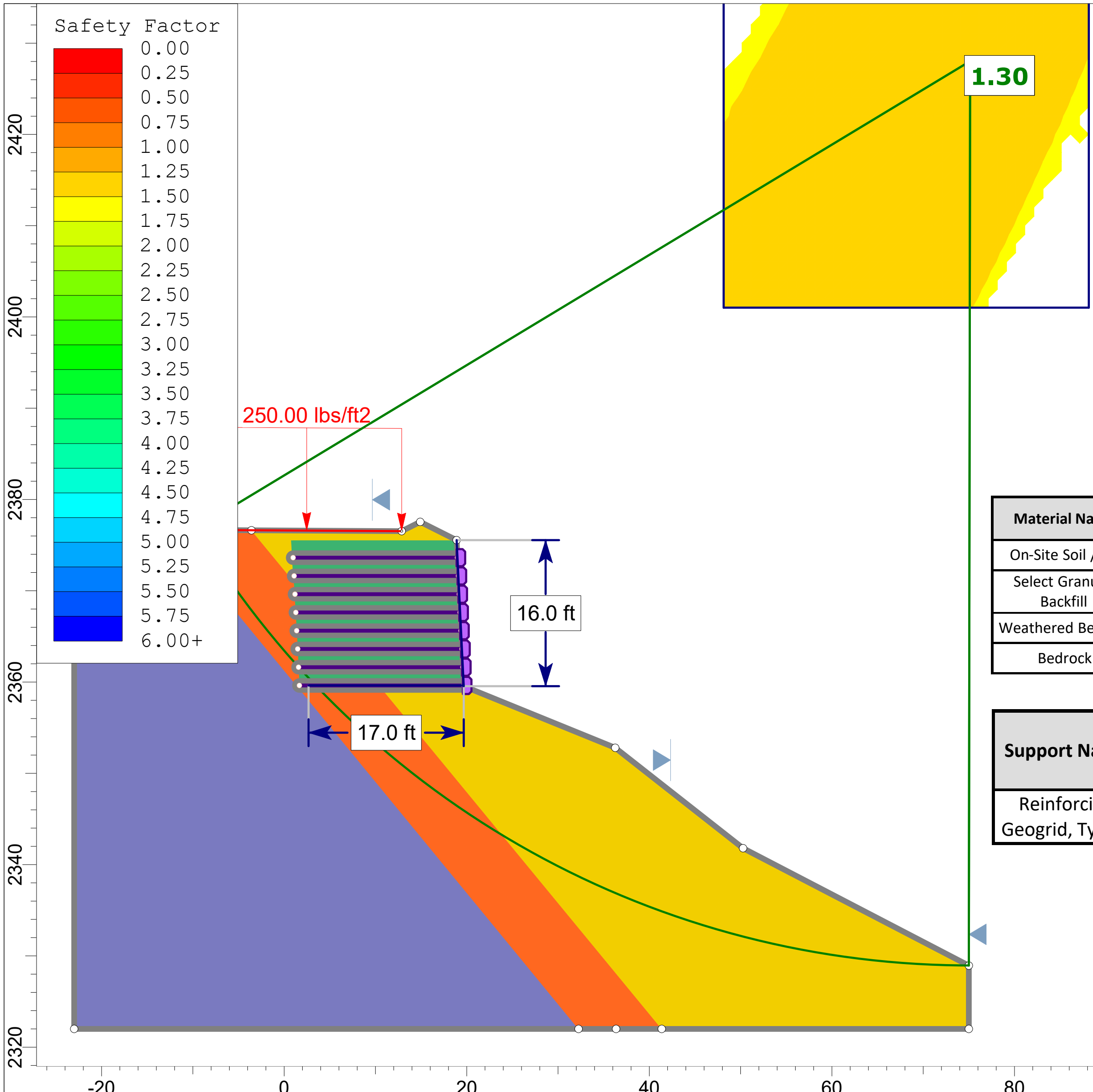


Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	32
Weathered Bedrock		140	200	32
Bedrock		140	500	32

U.S. Department of Transportation
Federal Highway Administration

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	Backanalysis	*Scenario*	Seismic
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 10.slmd

SLIDEINTERPRET 9.019



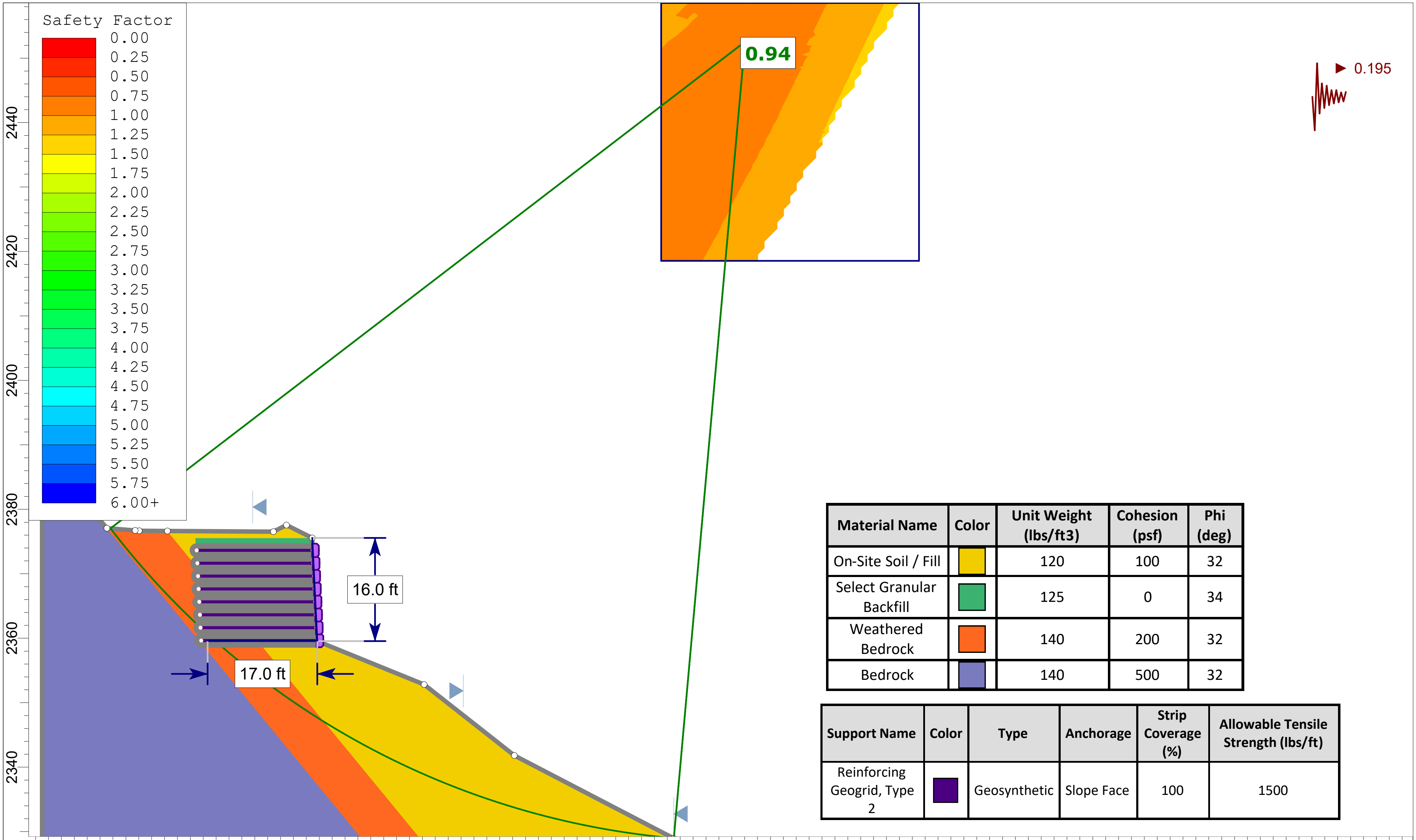
Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	32
Select Granular Backfill		125	0	34
Weathered Bedrock		140	200	32
Bedrock		140	500	32

Support Name	Color	Type	Anchorage	Strip Coverage (%)	Allowable Tensile Strength (lbs/ft)
Reinforcing Geogrid, Type 2		Geosynthetic	Slope Face	100	1500

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	MSE Wall - FS=1.3	*Scenario*	Static
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 10.slmd

U.S. Department of Transportation Federal Highway Administration

SLIDEINTERPRET 9.019



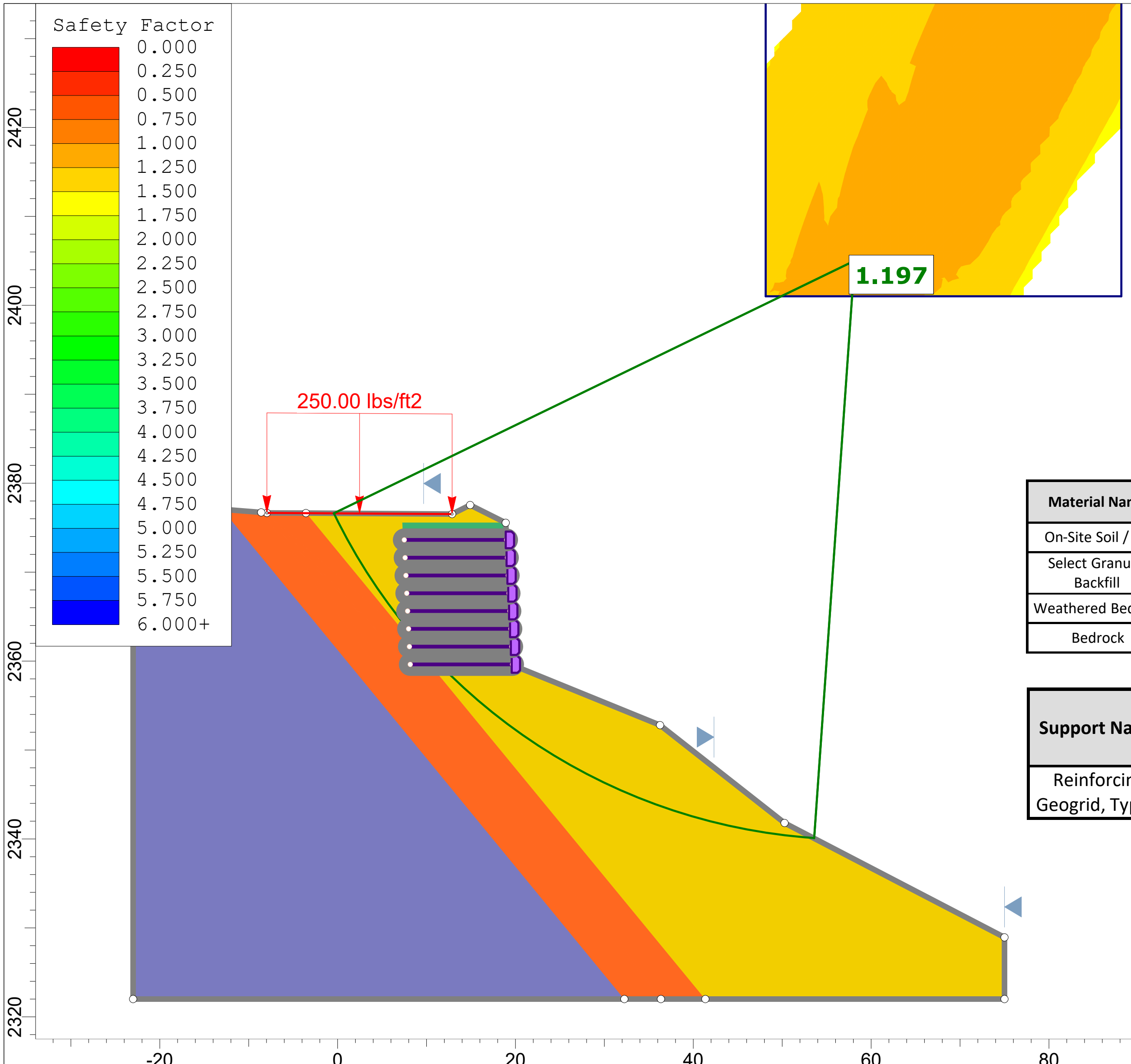
Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	32
Select Granular Backfill		125	0	34
Weathered Bedrock		140	200	32
Bedrock		140	500	32

Support Name	Color	Type	Anchorage	Strip Coverage (%)	Allowable Tensile Strength (lbs/ft)
Reinforcing Geogrid, Type 2		Geosynthetic	Slope Face	100	1500

U.S. Department of Transportation Federal Highway Administration

SLIDEINTERPRET 9.019

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	MSE Wall - FS=1.3	*Scenario*	Seismic
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 10.slmd



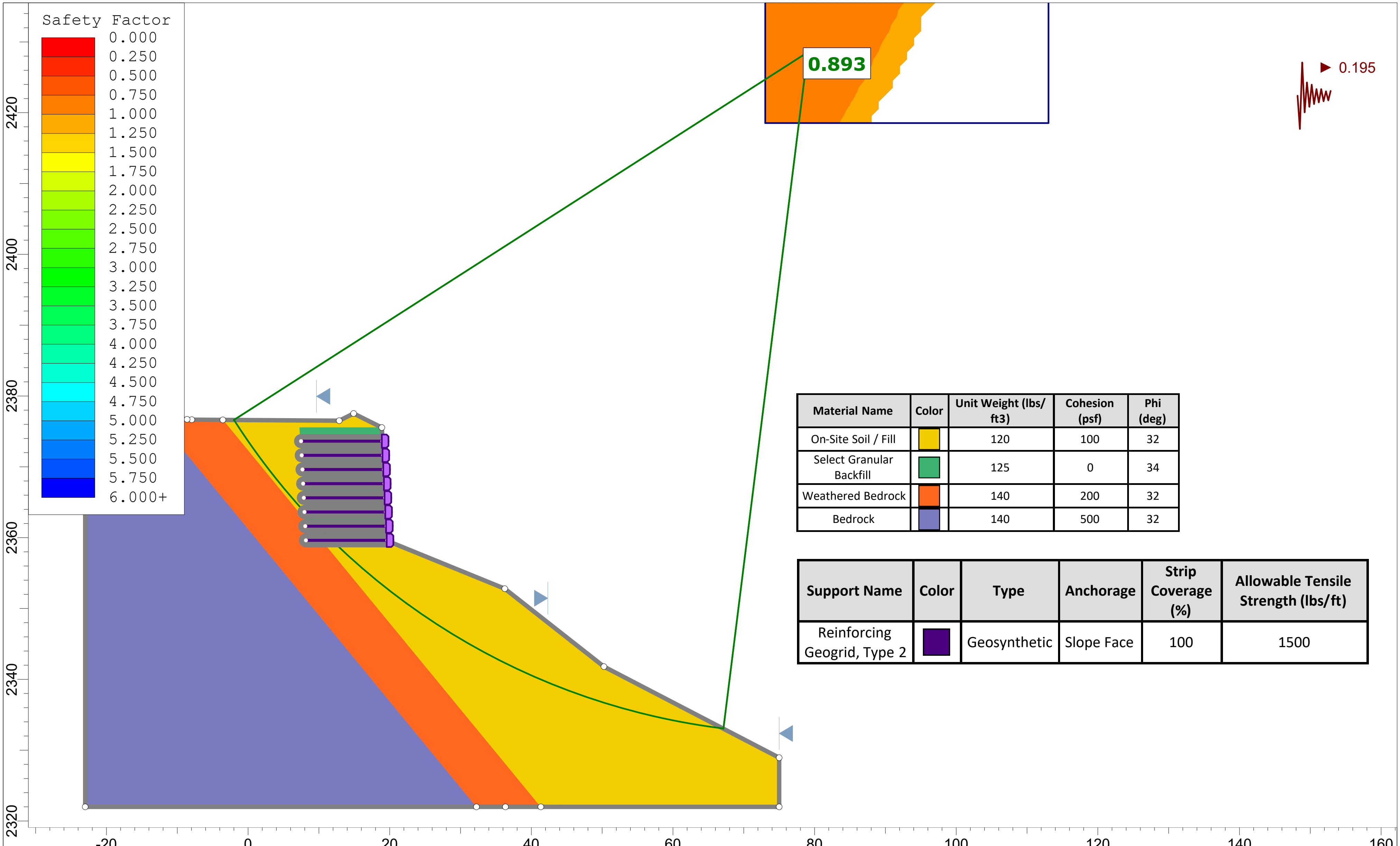
Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	32
Select Granular Backfill		125	0	34
Weathered Bedrock		140	200	32
Bedrock		140	500	32

Support Name	Color	Type	Anchorage	Strip Coverage (%)	Allowable Tensile Strength (lbs/ft)
Reinforcing Geogrid, Type 2		Geosynthetic	Slope Face	100	1500

U.S. Department of Transportation Federal Highway Administration

SLIDEINTERPRET 9.019

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	MSE Wall - RL=70%	*Scenario*	Static
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 10.slmd



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	32
Select Granular Backfill		125	0	34
Weathered Bedrock		140	200	32
Bedrock		140	500	32

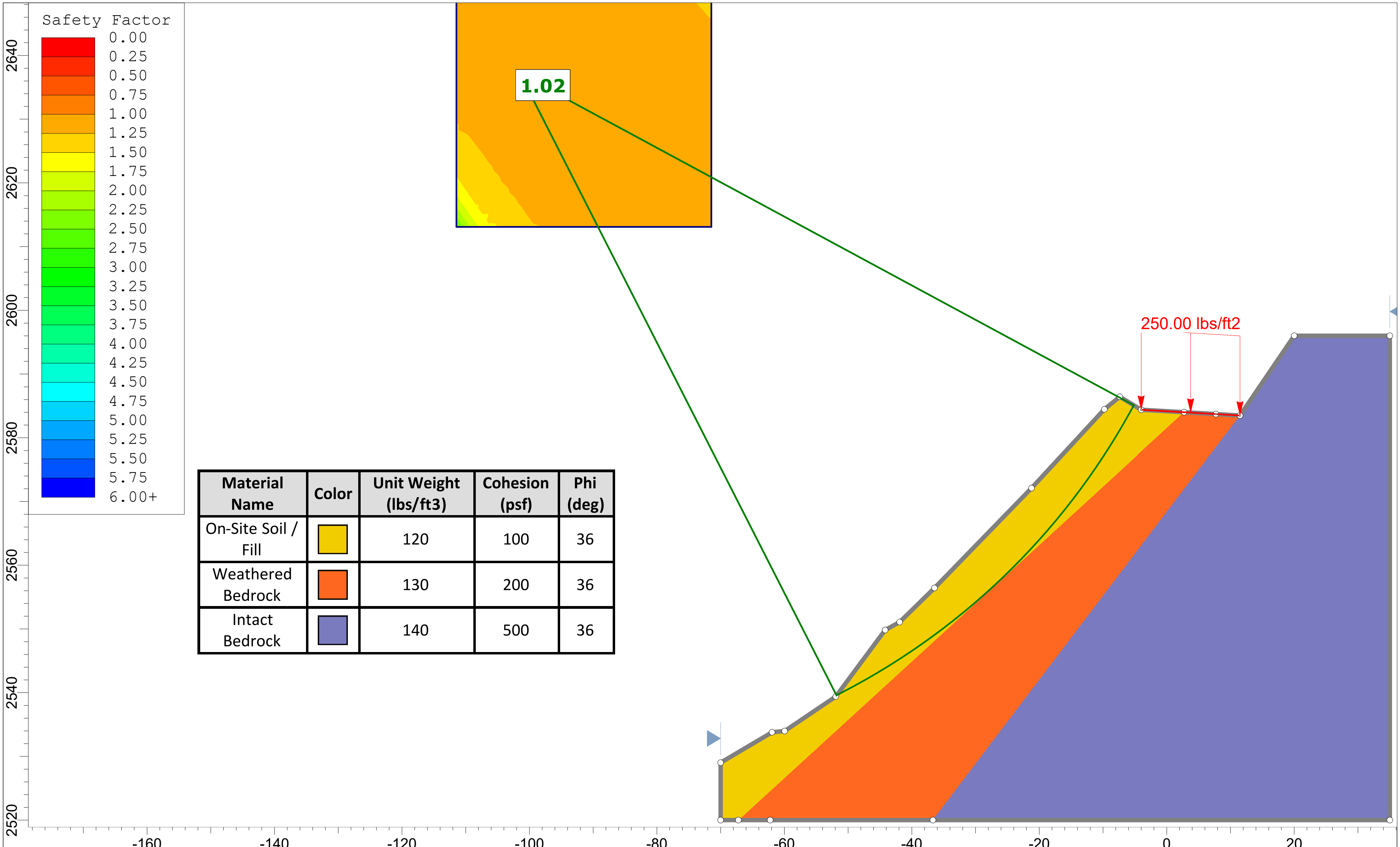
Support Name	Color	Type	Anchorage	Strip Coverage (%)	Allowable Tensile Strength (lbs/ft)
Reinforcing Geogrid, Type 2		Geosynthetic	Slope Face	100	1500

U.S. Department of Transportation Federal Highway Administration

SLIDEINTERPRET 9.019

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	MSE Wall - RL=70%	*Scenario*	Seismic
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 10.slmd

Site 13

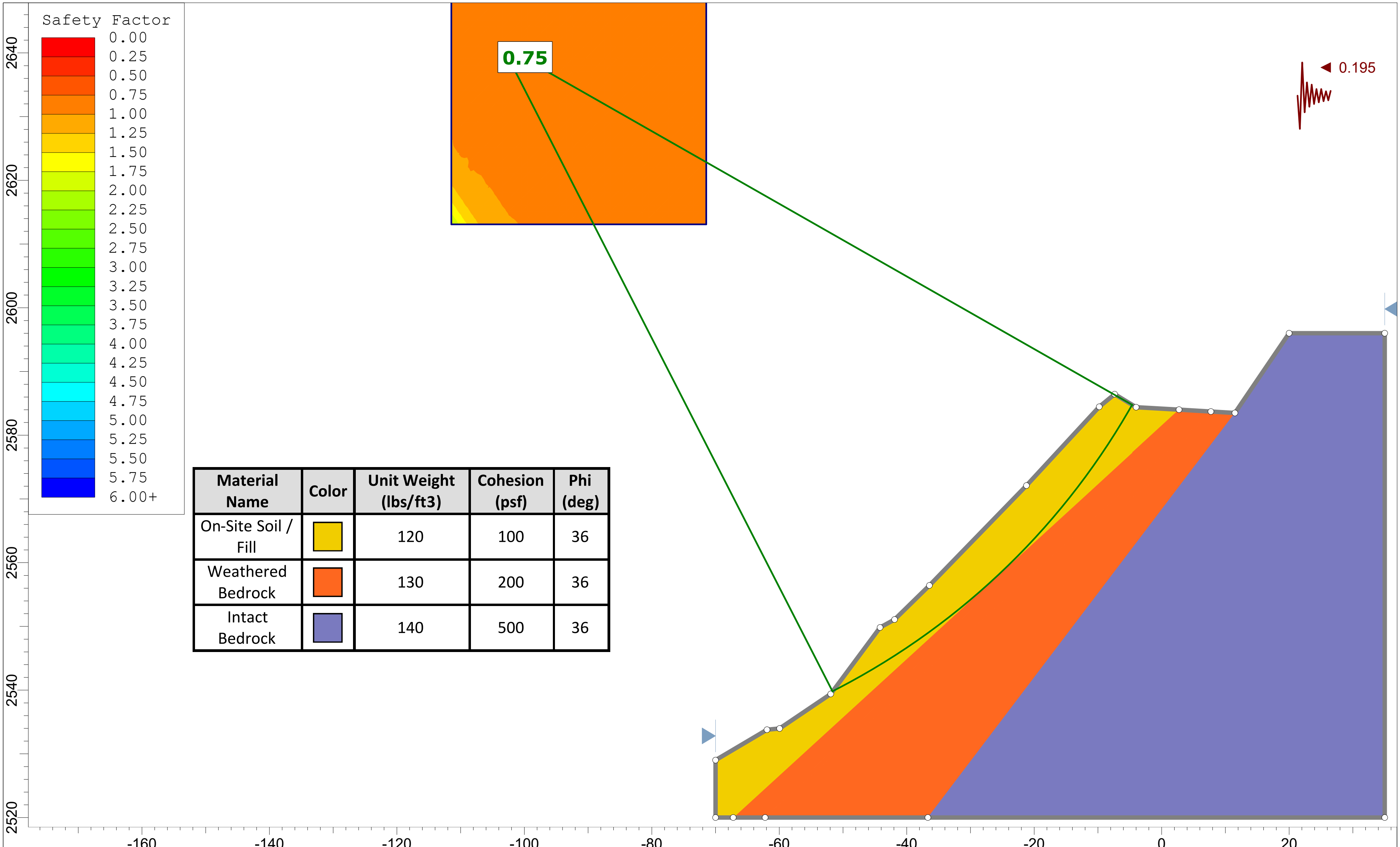


Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	36
Weathered Bedrock		130	200	36
Intact Bedrock		140	500	36

U.S. Department of Transportation Federal Highway Administration

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	Backanalysis	*Scenario*	Static
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 13.slmd

SLIDEINTERPRET 9.019

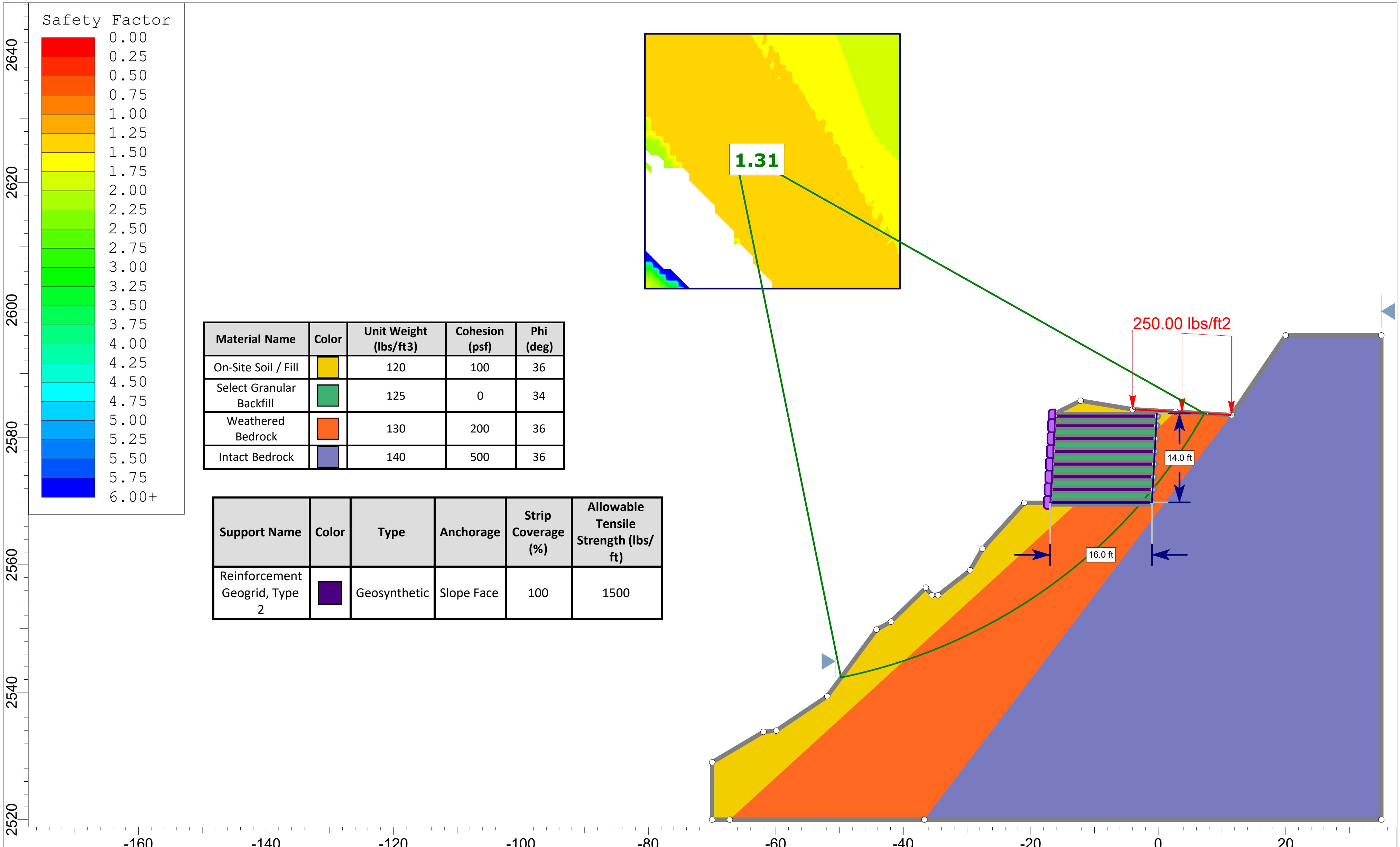


Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	36
Weathered Bedrock		130	200	36
Intact Bedrock		140	500	36

U.S. Department of Transportation Federal Highway Administration

SLIDEINTERPRET 9.019

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	Backanalysis	*Scenario*	Seismic
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 13.slmd



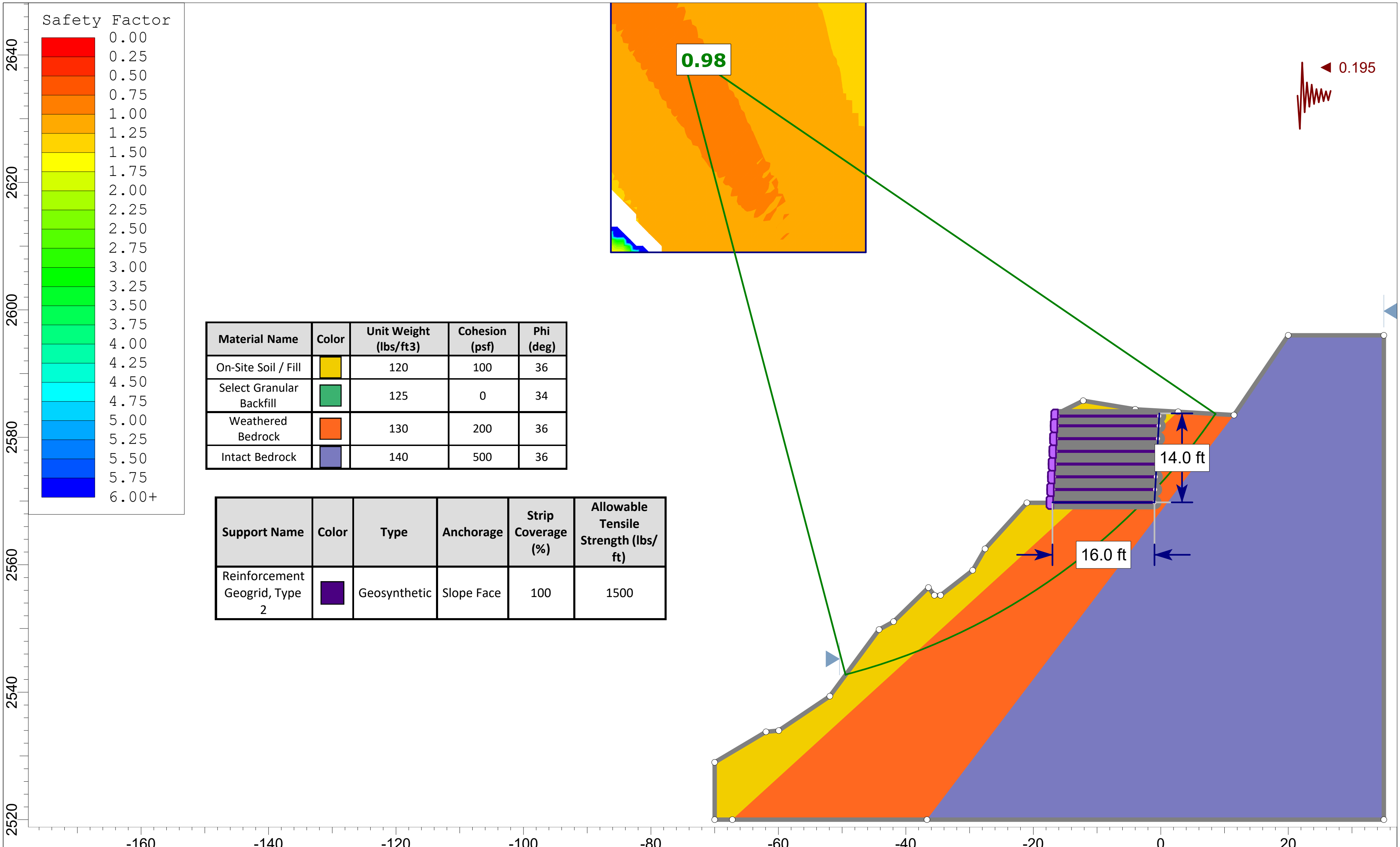
Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	36
Select Granular Backfill		125	0	34
Weathered Bedrock		130	200	36
Intact Bedrock		140	500	36

Support Name	Color	Type	Anchorage	Strip Coverage (%)	Allowable Tensile Strength (lbs/ft)
Reinforcement Geogrid, Type 2		Geosynthetic	Slope Face	100	1500

U.S. Department of Transportation Federal Highway Administration

SLIDEINTERPRET 9.019

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	MSE Wall - FS=1.3	*Scenario*	Static
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 13.slmd



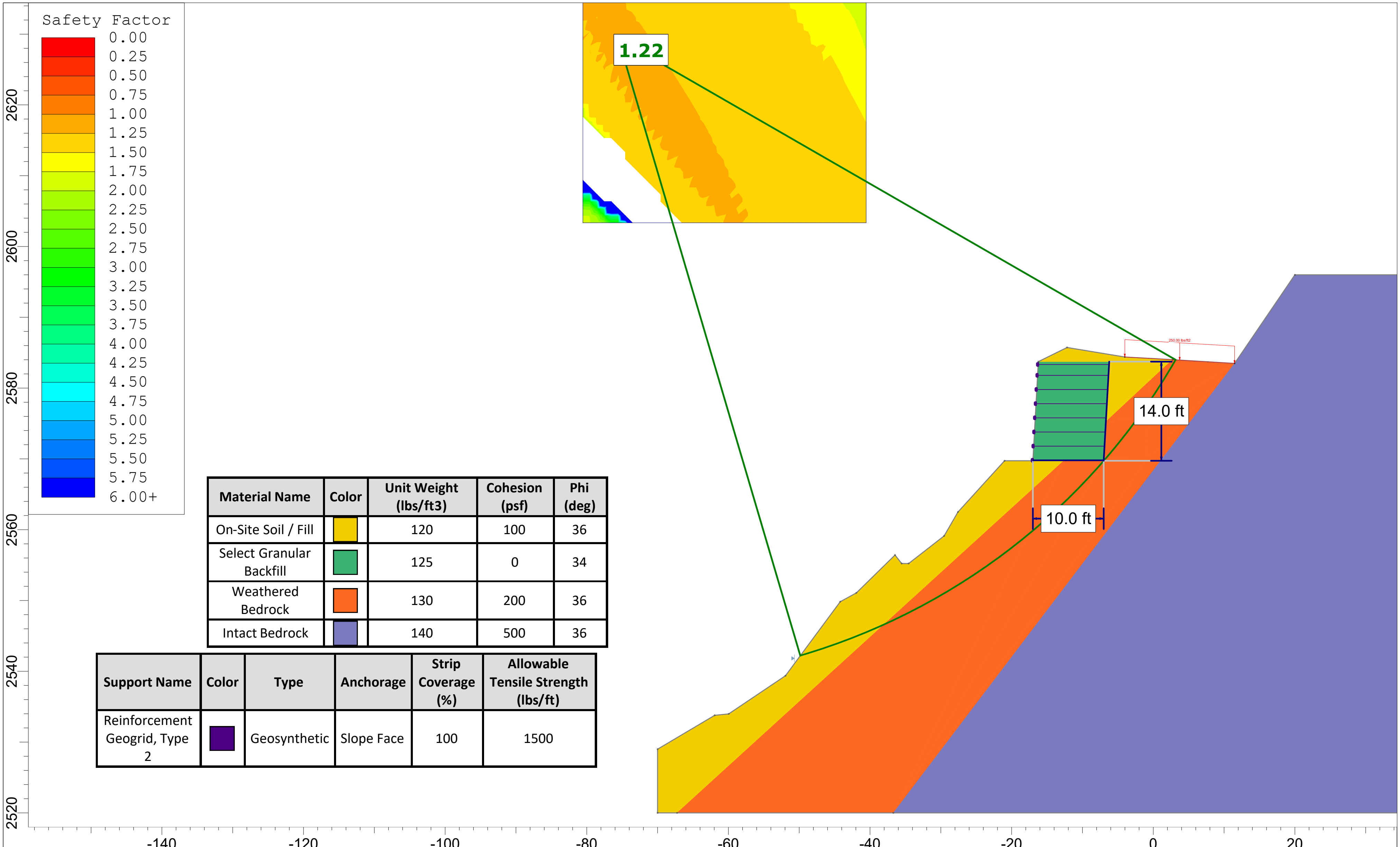
Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	36
Select Granular Backfill		125	0	34
Weathered Bedrock		130	200	36
Intact Bedrock		140	500	36

Support Name	Color	Type	Anchorage	Strip Coverage (%)	Allowable Tensile Strength (lbs/ft)
Reinforcement Geogrid, Type 2		Geosynthetic	Slope Face	100	1500

U.S. Department of Transportation
Federal Highway Administration

SLIDEINTERPRET 9.019

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	MSE Wall - FS=1.3	*Scenario*	Seismic
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 13.slmd



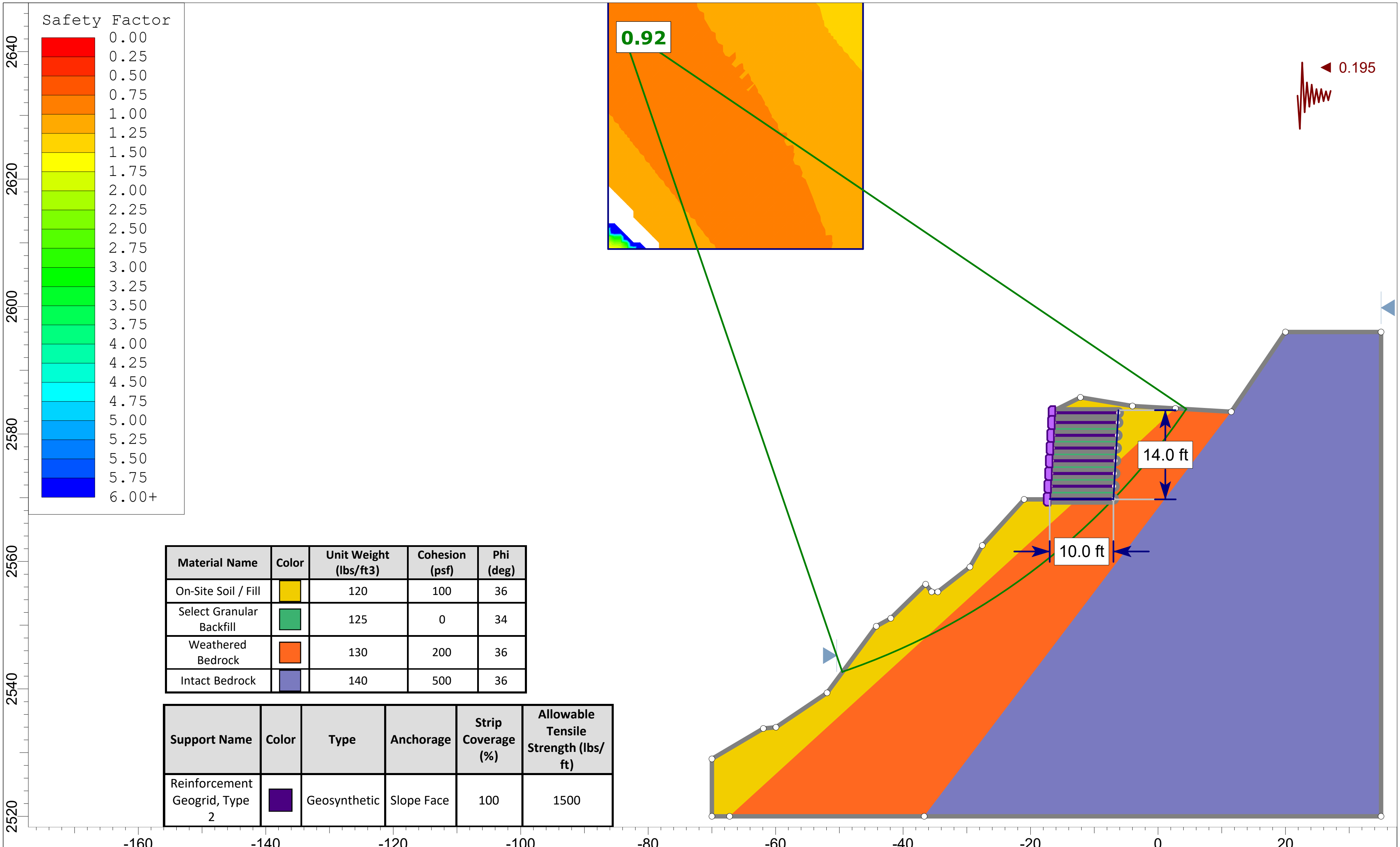
Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	36
Select Granular Backfill		125	0	34
Weathered Bedrock		130	200	36
Intact Bedrock		140	500	36

Support Name	Color	Type	Anchorage	Strip Coverage (%)	Allowable Tensile Strength (lbs/ft)
Reinforcement Geogrid, Type 2		Geosynthetic	Slope Face	100	1500

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	MSE Wall RL=70%	*Scenario*	Static
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 13.slmd

U.S. Department of Transportation Federal Highway Administration

SLIDEINTERPRET 9.019



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	36
Select Granular Backfill		125	0	34
Weathered Bedrock		130	200	36
Intact Bedrock		140	500	36

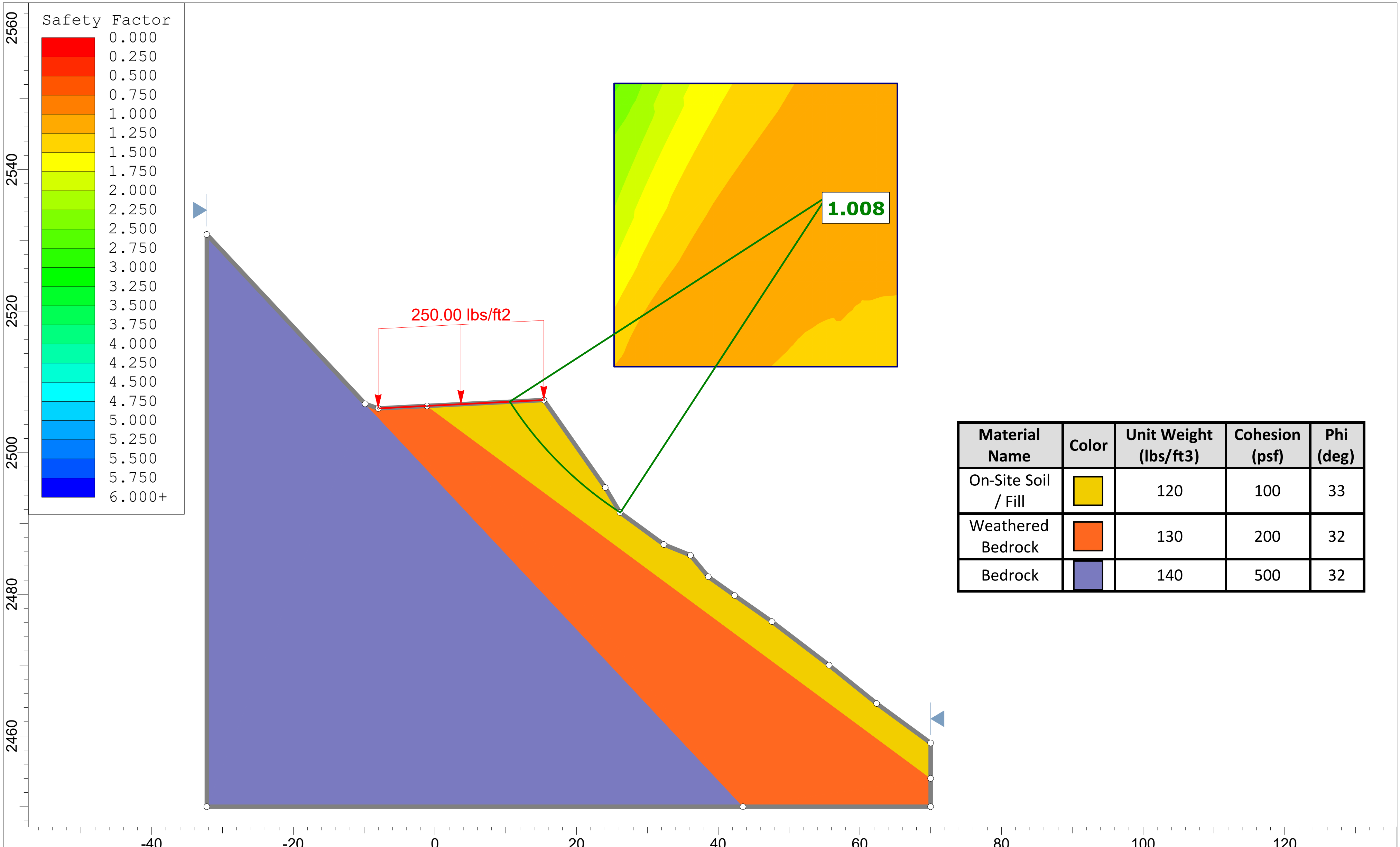
Support Name	Color	Type	Anchorage	Strip Coverage (%)	Allowable Tensile Strength (lbs/ft)
Reinforcement Geogrid, Type 2		Geosynthetic	Slope Face	100	1500

U.S. Department of Transportation Federal Highway Administration

SLIDEINTERPRET 9.019

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	MSE Wall RL=70%	*Scenario*	Seismic
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 13.slmd

Site 14

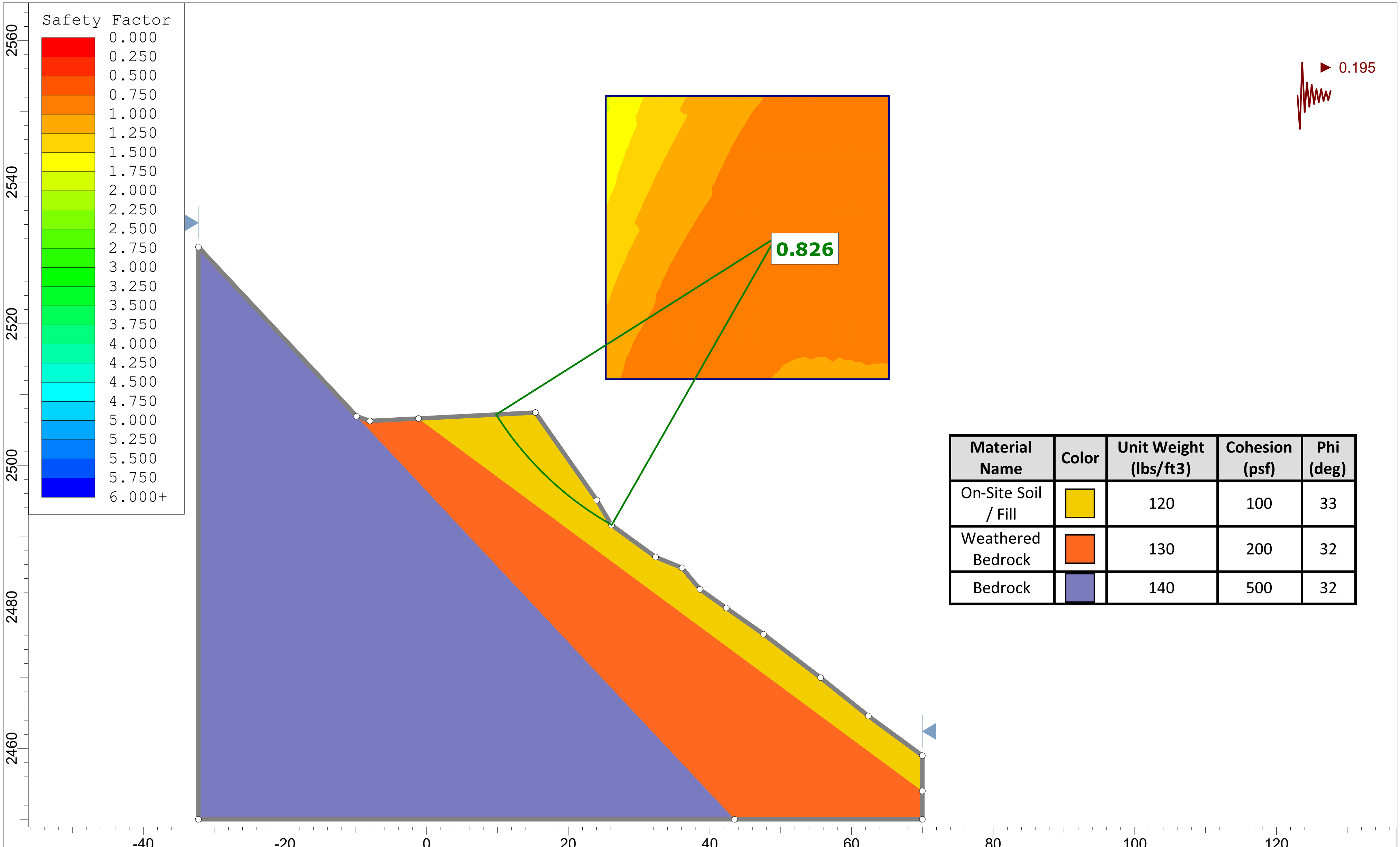


Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	33
Weathered Bedrock		130	200	32
Bedrock		140	500	32

U.S. Department of Transportation
Federal Highway Administration

SLIDEINTERPRET 9.019

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	Backanalysis	Scenario	Static
Drawn By	JMA	Company	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	File Name	Site 14.slmd

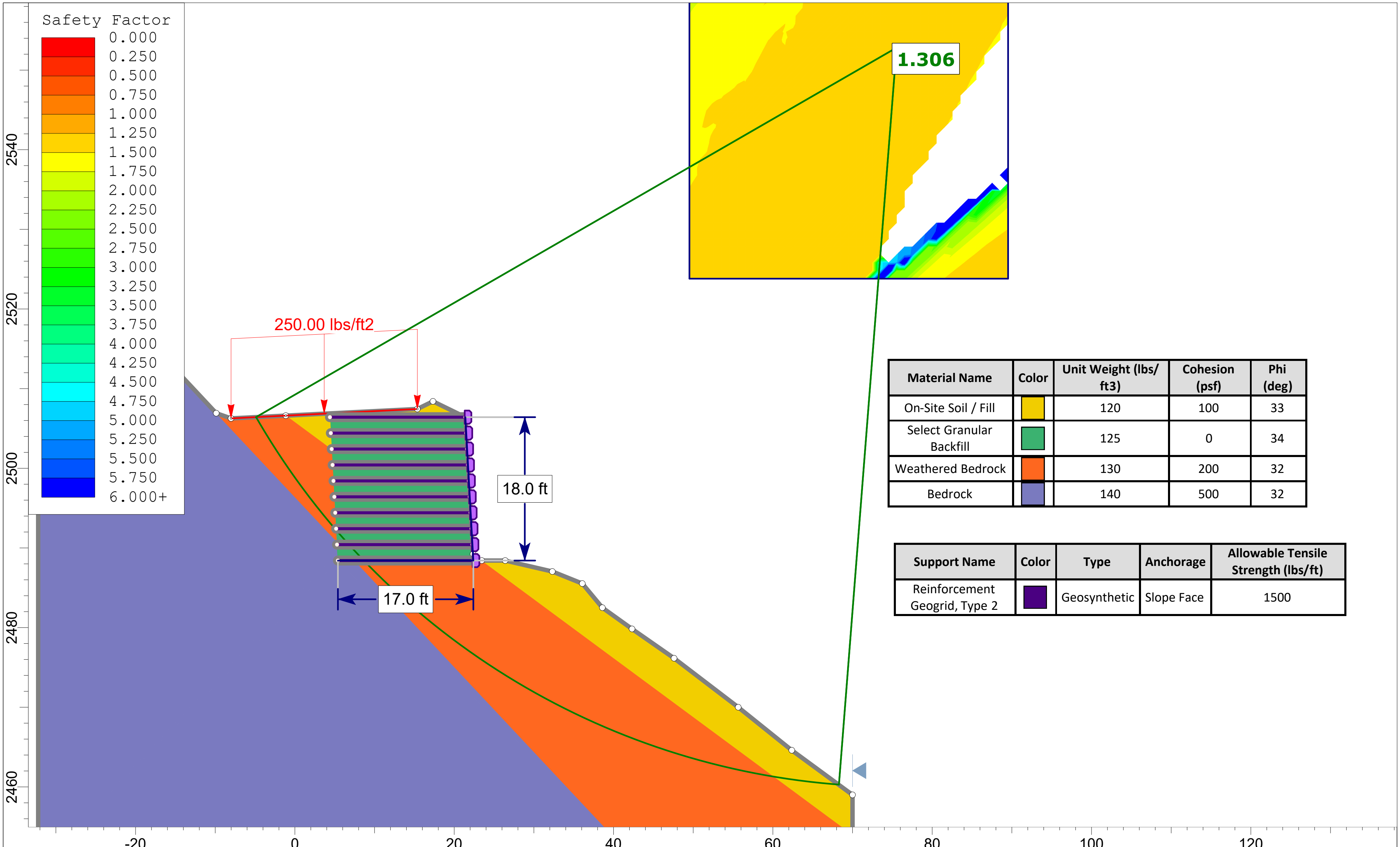


Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	33
Weathered Bedrock		130	200	32
Bedrock		140	500	32

U.S. Department of Transportation
Federal Highway Administration

SLIDEINTERPRET 9.019

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	Backanalysis	*Scenario*	Seismic
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 14.slmd



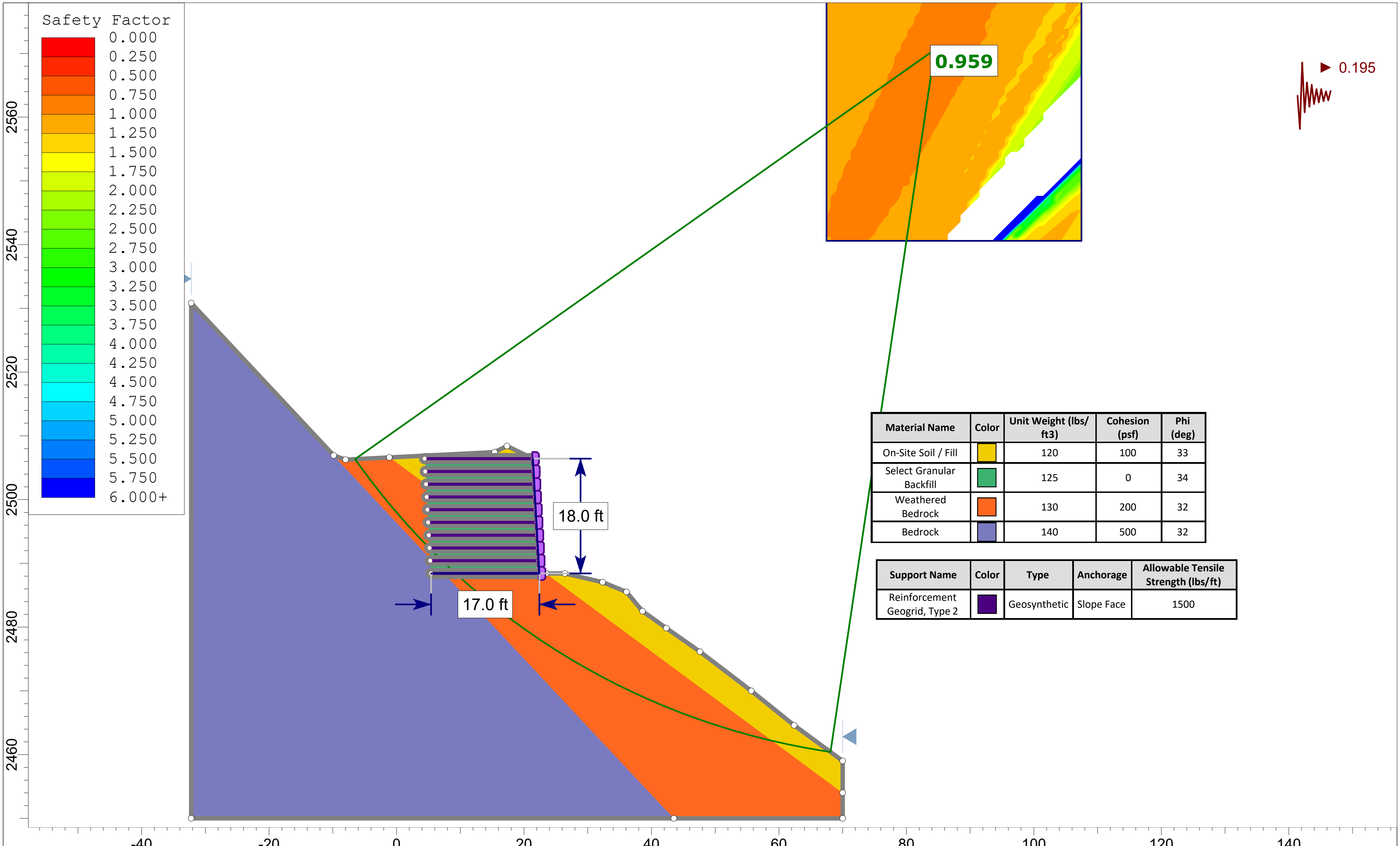
Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	33
Select Granular Backfill		125	0	34
Weathered Bedrock		130	200	32
Bedrock		140	500	32

Support Name	Color	Type	Anchorage	Allowable Tensile Strength (lbs/ft)
Reinforcement Geogrid, Type 2		Geosynthetic	Slope Face	1500

U.S. Department of Transportation Federal Highway Administration

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	MSE Wall - FS=1.3	*Scenario*	Static
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 14.slmd

SLIDEINTERPRET 9.019



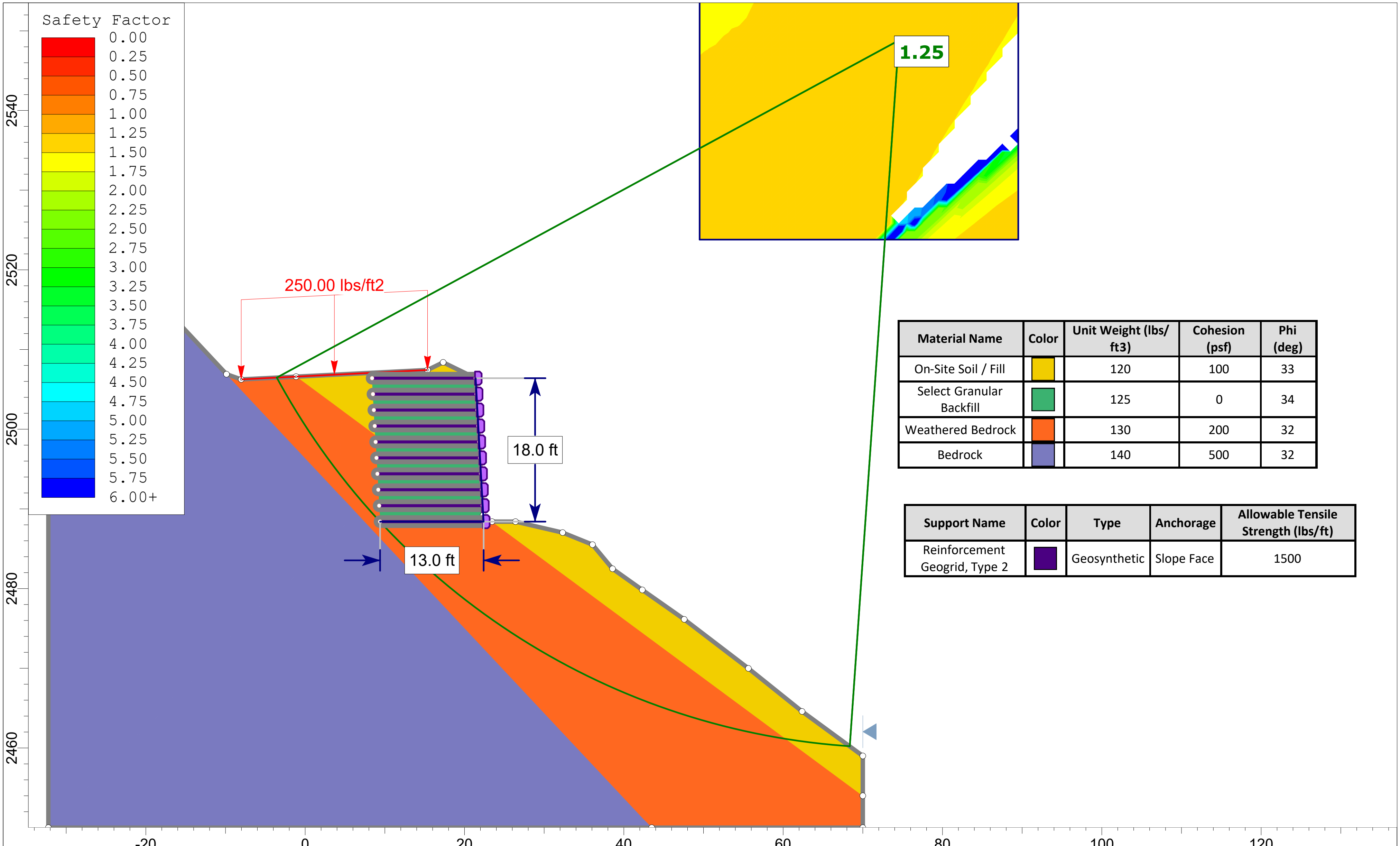
Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	33
Select Granular Backfill		125	0	34
Weathered Bedrock		130	200	32
Bedrock		140	500	32

Support Name	Color	Type	Anchorage	Allowable Tensile Strength (lbs/ft)
Reinforcement Geogrid, Type 2		Geosynthetic	Slope Face	1500

U.S. Department of Transportation Federal Highway Administration

SLIDEINTERPRET 9.019

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	MSE Wall - FS=1.3	*Scenario*	Seismic
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 14.slmd



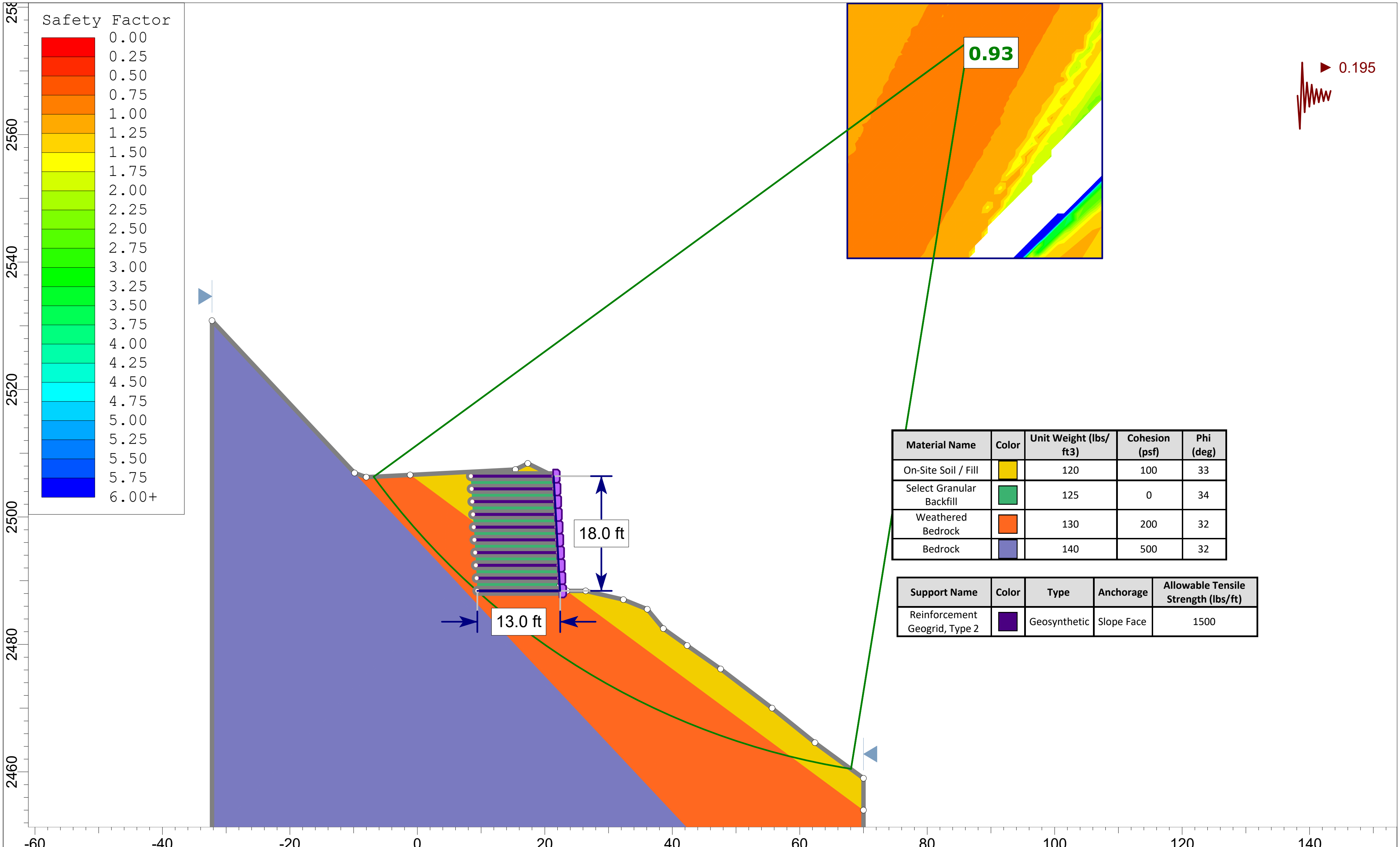
Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	33
Select Granular Backfill		125	0	34
Weathered Bedrock		130	200	32
Bedrock		140	500	32

Support Name	Color	Type	Anchorage	Allowable Tensile Strength (lbs/ft)
Reinforcement Geogrid, Type 2		Geosynthetic	Slope Face	1500

U.S. Department of Transportation Federal Highway Administration

SLIDEINTERPRET 9.019

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	MSE Wall RL=70%	*Scenario*	Static
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 14.slmd



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	33
Select Granular Backfill		125	0	34
Weathered Bedrock		130	200	32
Bedrock		140	500	32

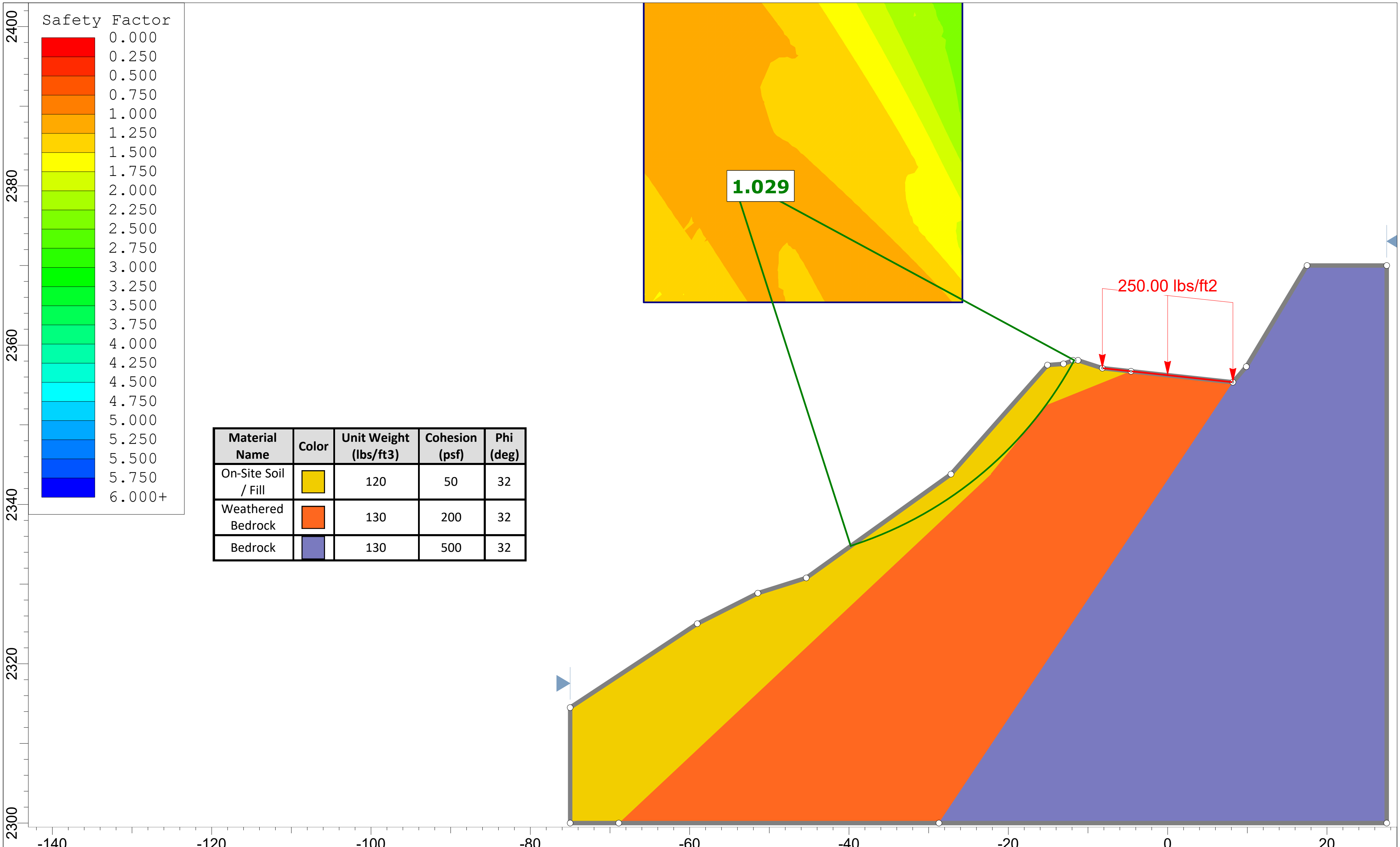
Support Name	Color	Type	Anchorage	Allowable Tensile Strength (lbs/ft)
Reinforcement Geogrid, Type 2		Geosynthetic	Slope Face	1500

U.S. Department of Transportation Federal Highway Administration

SLIDEINTERPRET 9.019

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	MSE Wall RL=70%	*Scenario*	Seismic
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 14.slmd

Site 15

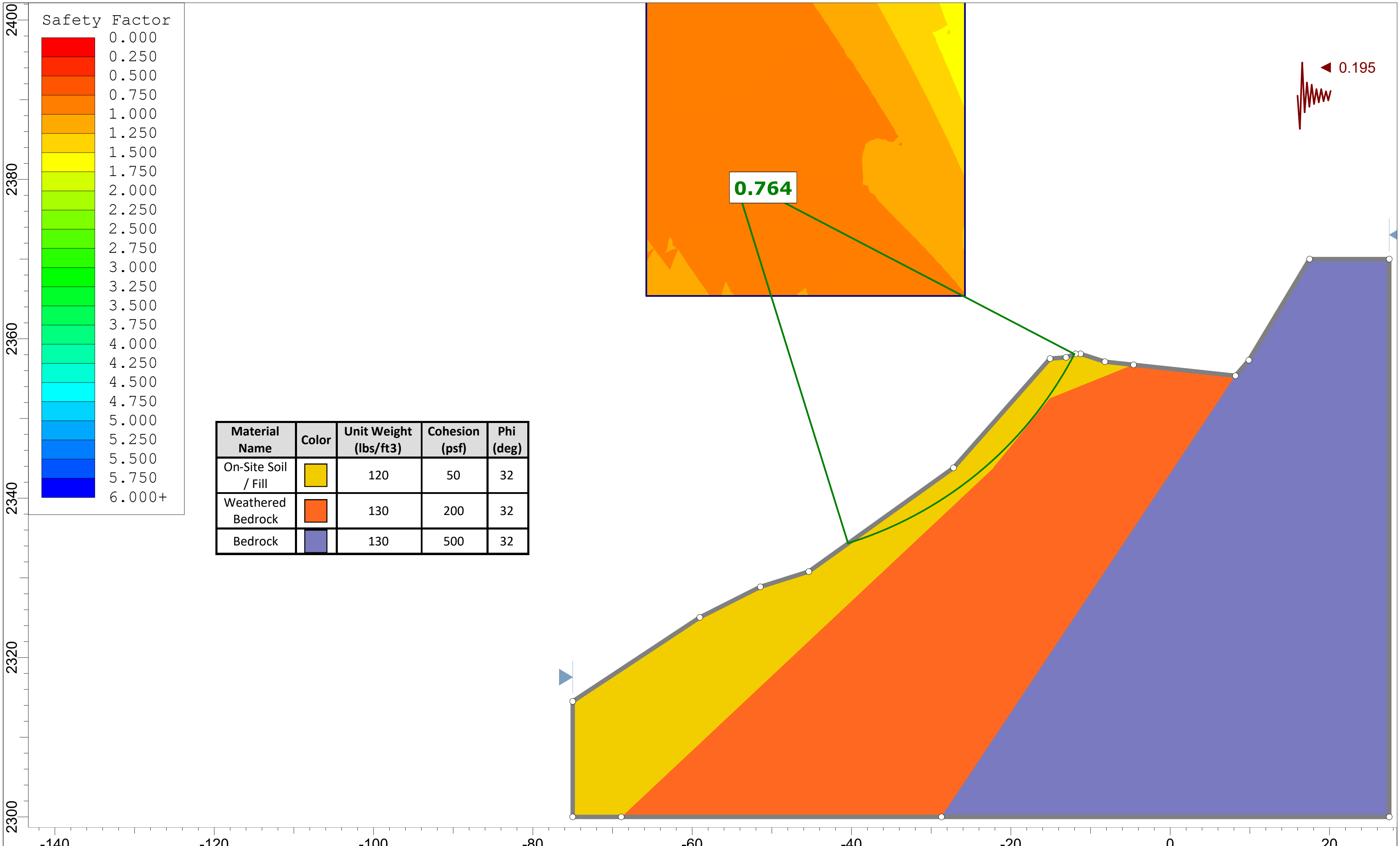


Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	50	32
Weathered Bedrock		130	200	32
Bedrock		130	500	32

U.S. Department of Transportation Federal Highway Administration

SLIDEINTERPRET 9.019

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	Backanalysis	*Scenario*	Static
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 15.slmd



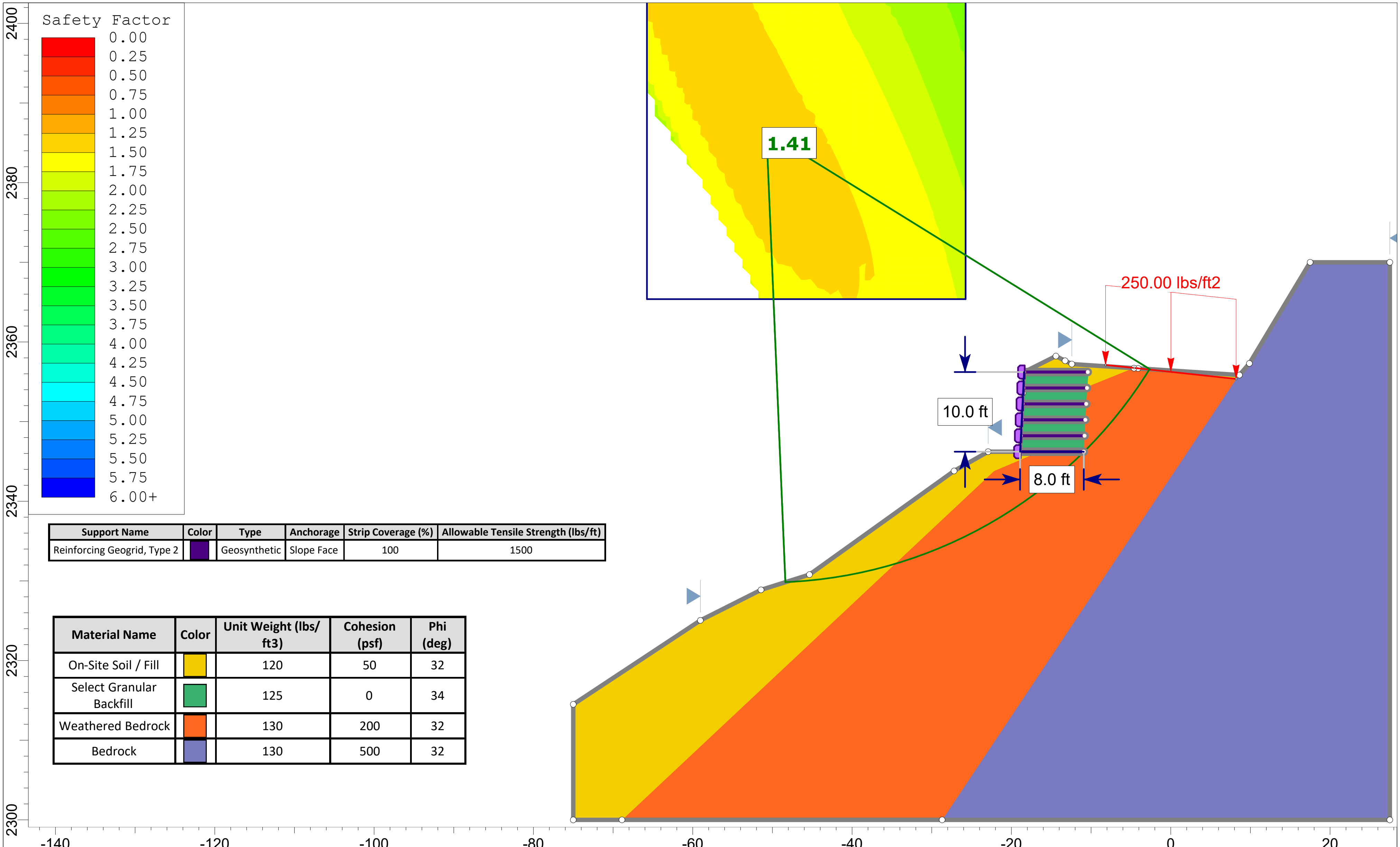
Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	50	32
Weathered Bedrock		130	200	32
Bedrock		130	500	32

U.S. Department of Transportation Federal Highway Administration

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd

Group	Backanalysis	*Scenario*	Seismic
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 15.slmd

SLIDEINTERPRET 9.019



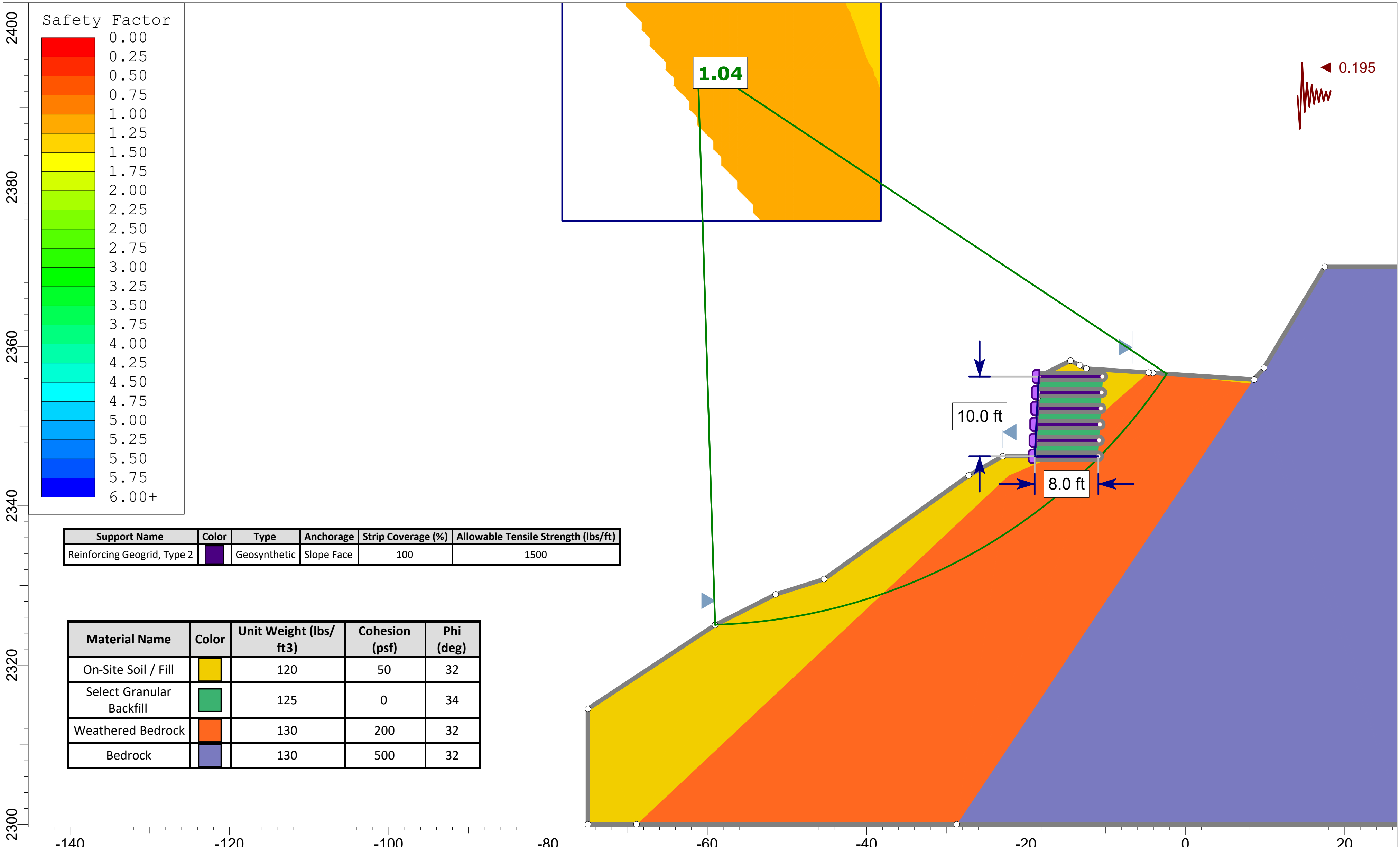
Support Name	Color	Type	Anchorage	Strip Coverage (%)	Allowable Tensile Strength (lbs/ft)
Reinforcing Geogrid, Type 2		Geosynthetic	Slope Face	100	1500

Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	50	32
Select Granular Backfill		125	0	34
Weathered Bedrock		130	200	32
Bedrock		130	500	32

U.S. Department of Transportation Federal Highway Administration

SLIDEINTERPRET 9.019

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	MSE Wall - FS=1.3	*Scenario*	Static
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 15.slmd



Support Name	Color	Type	Anchorage	Strip Coverage (%)	Allowable Tensile Strength (lbs/ft)
Reinforcing Geogrid, Type 2		Geosynthetic	Slope Face	100	1500

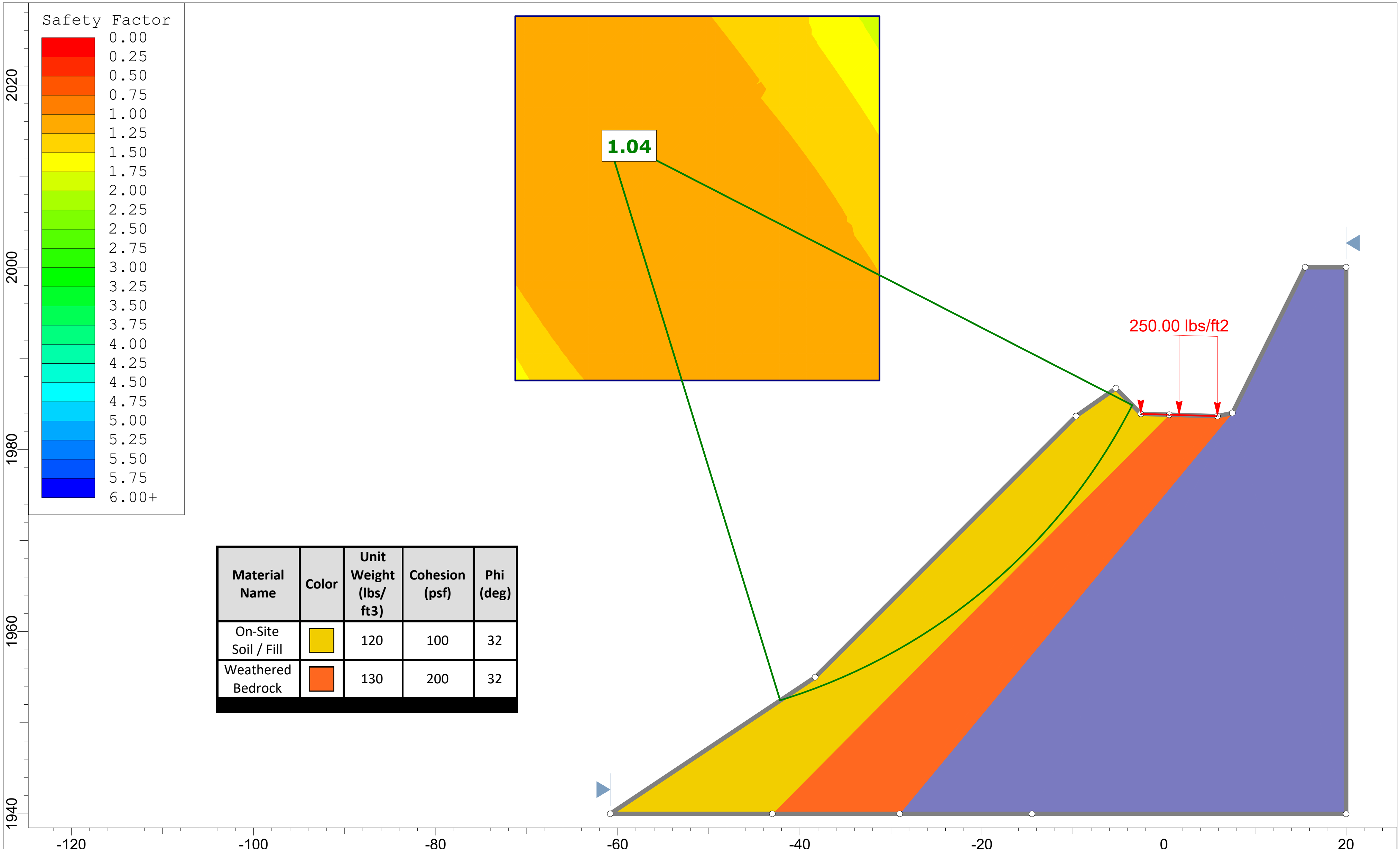
Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	50	32
Select Granular Backfill		125	0	34
Weathered Bedrock		130	200	32
Bedrock		130	500	32

U.S. Department of Transportation Federal Highway Administration

SLIDEINTERPRET 9.019

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd
Group	MSE Wall - FS=1.3
Scenario	Seismic
Drawn By	JMA
Company	FHWA-CFL
Date	8/10/2022, 12:35:01 PM
File Name	Site 15.slmd

Site 16

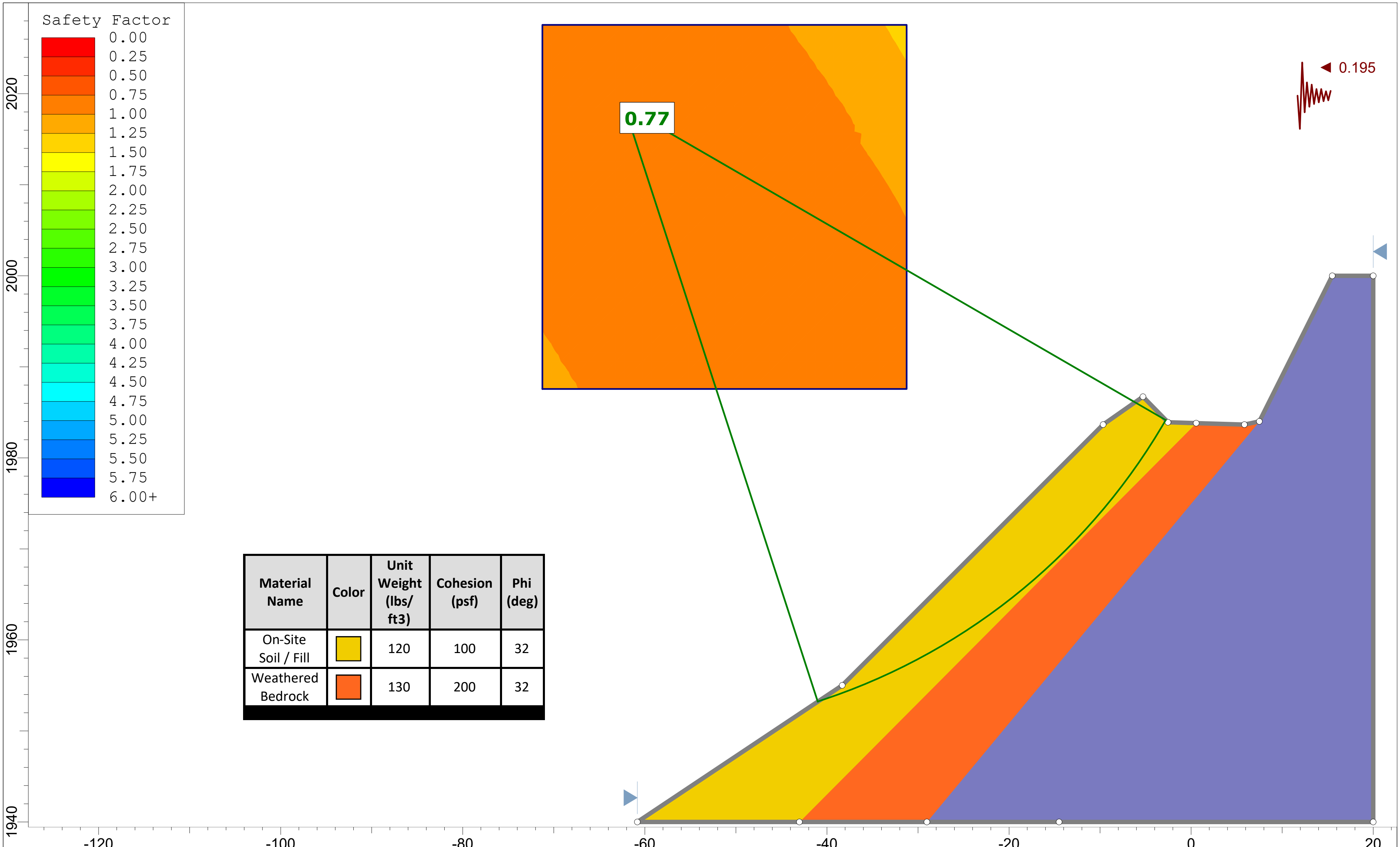


Material Name	Color	Unit Weight (lbs/ ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	32
Weathered Bedrock		130	200	32

U.S. Department of Transportation
Federal Highway Administration

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	Backanalysis	*Scenario*	Static
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 16.slmd

SLIDEINTERPRET 9.019

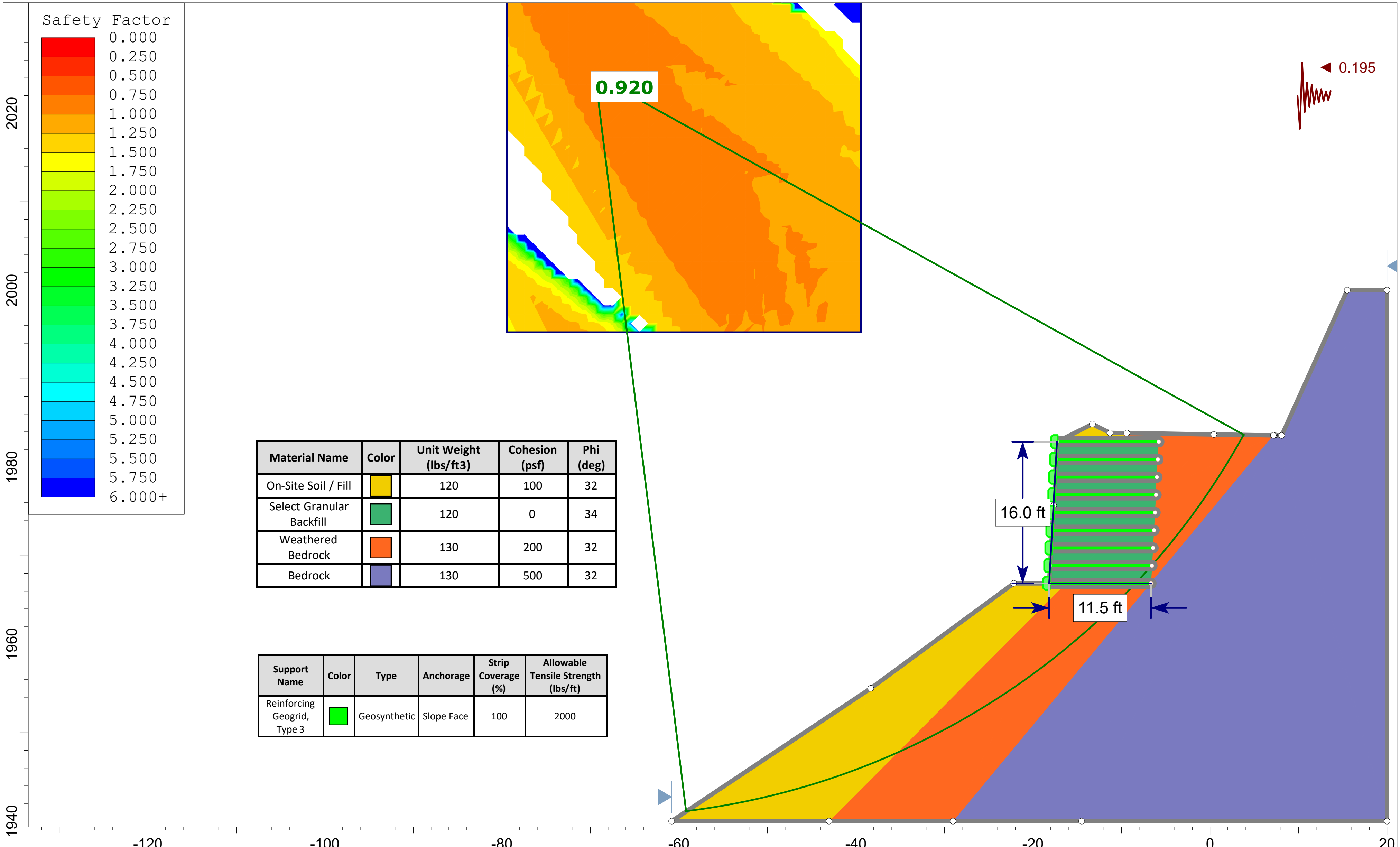


Material Name	Color	Unit Weight (lbs/ ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	32
Weathered Bedrock		130	200	32

U.S. Department of Transportation
Federal Highway Administration

SLIDEINTERPRET 9.019

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	Backanalysis	*Scenario*	Seismic
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 16.slmd



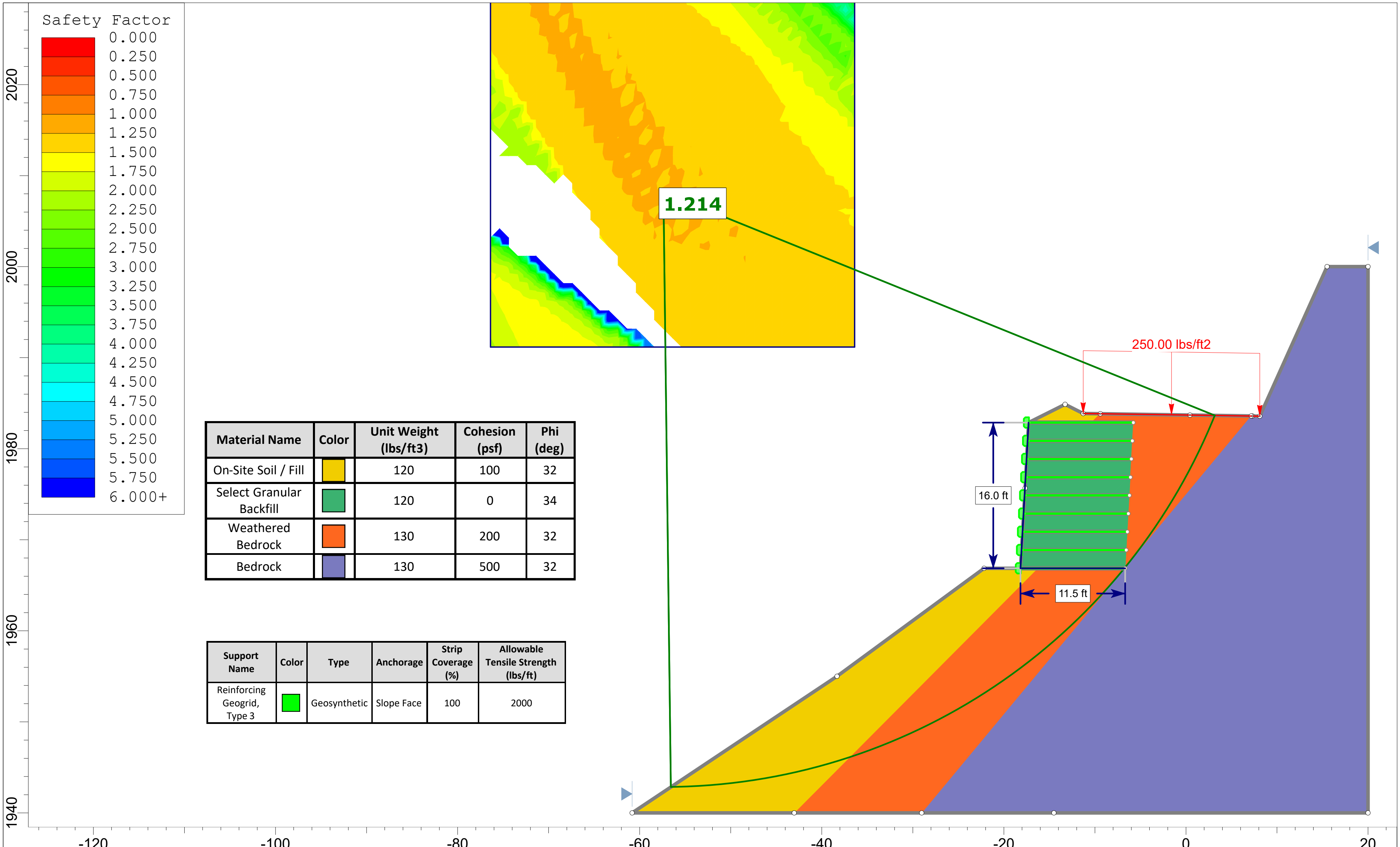
Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	32
Select Granular Backfill		120	0	34
Weathered Bedrock		130	200	32
Bedrock		130	500	32

Support Name	Color	Type	Anchorage	Strip Coverage (%)	Allowable Tensile Strength (lbs/ft)
Reinforcing Geogrid, Type 3		Geosynthetic	Slope Face	100	2000

U.S. Department of Transportation Federal Highway Administration

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	MSE Wall - L=70%	*Scenario*	Seismic
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 16.slmd

SLIDEINTERPRET 9.019



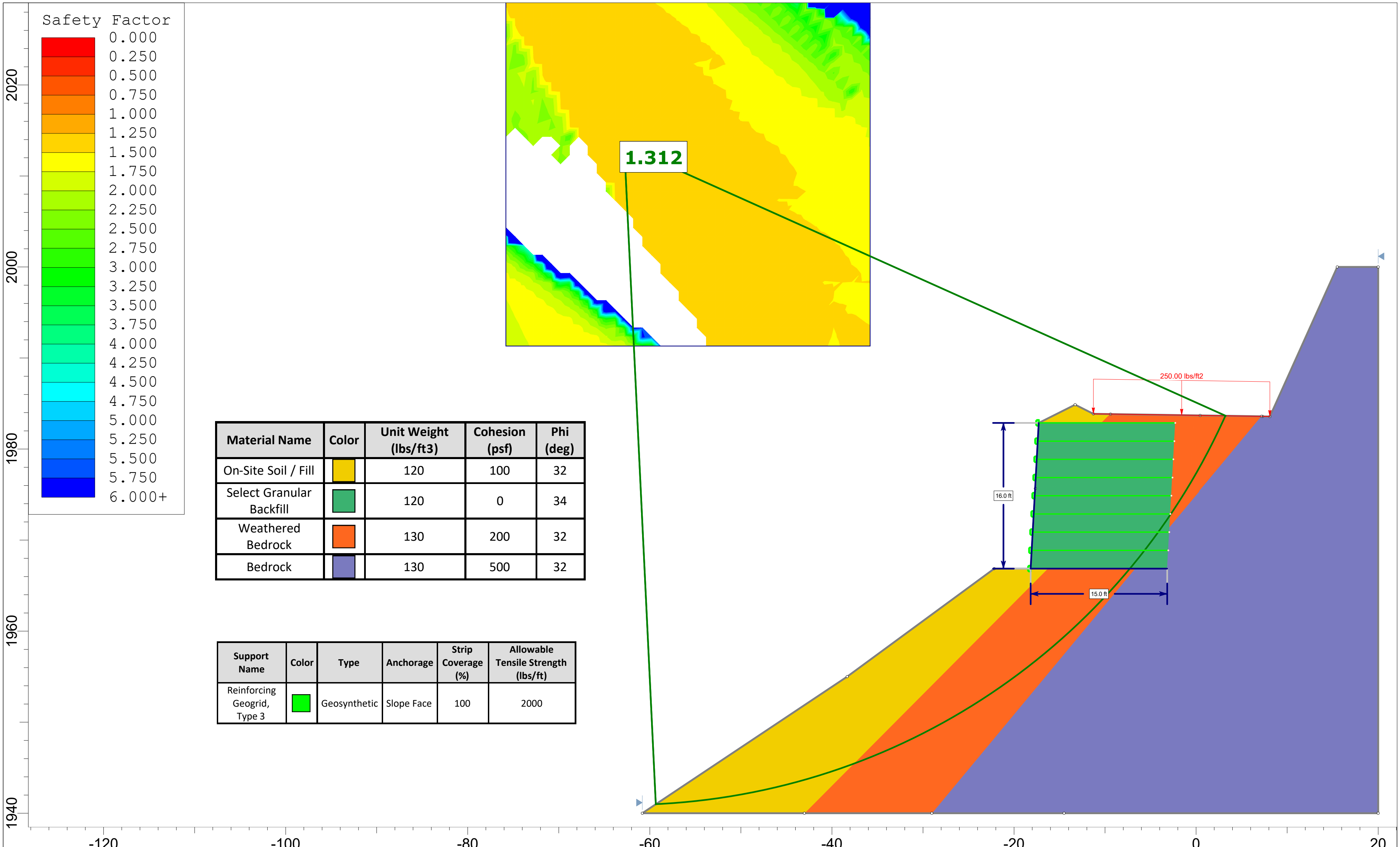
Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	32
Select Granular Backfill		120	0	34
Weathered Bedrock		130	200	32
Bedrock		130	500	32

Support Name	Color	Type	Anchorage	Strip Coverage (%)	Allowable Tensile Strength (lbs/ft)
Reinforcing Geogrid, Type 3		Geosynthetic	Slope Face	100	2000

U.S. Department of Transportation Federal Highway Administration

SLIDEINTERPRET 9.019

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	MSE Wall - L=70%	*Scenario*	Static
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 16.slmd



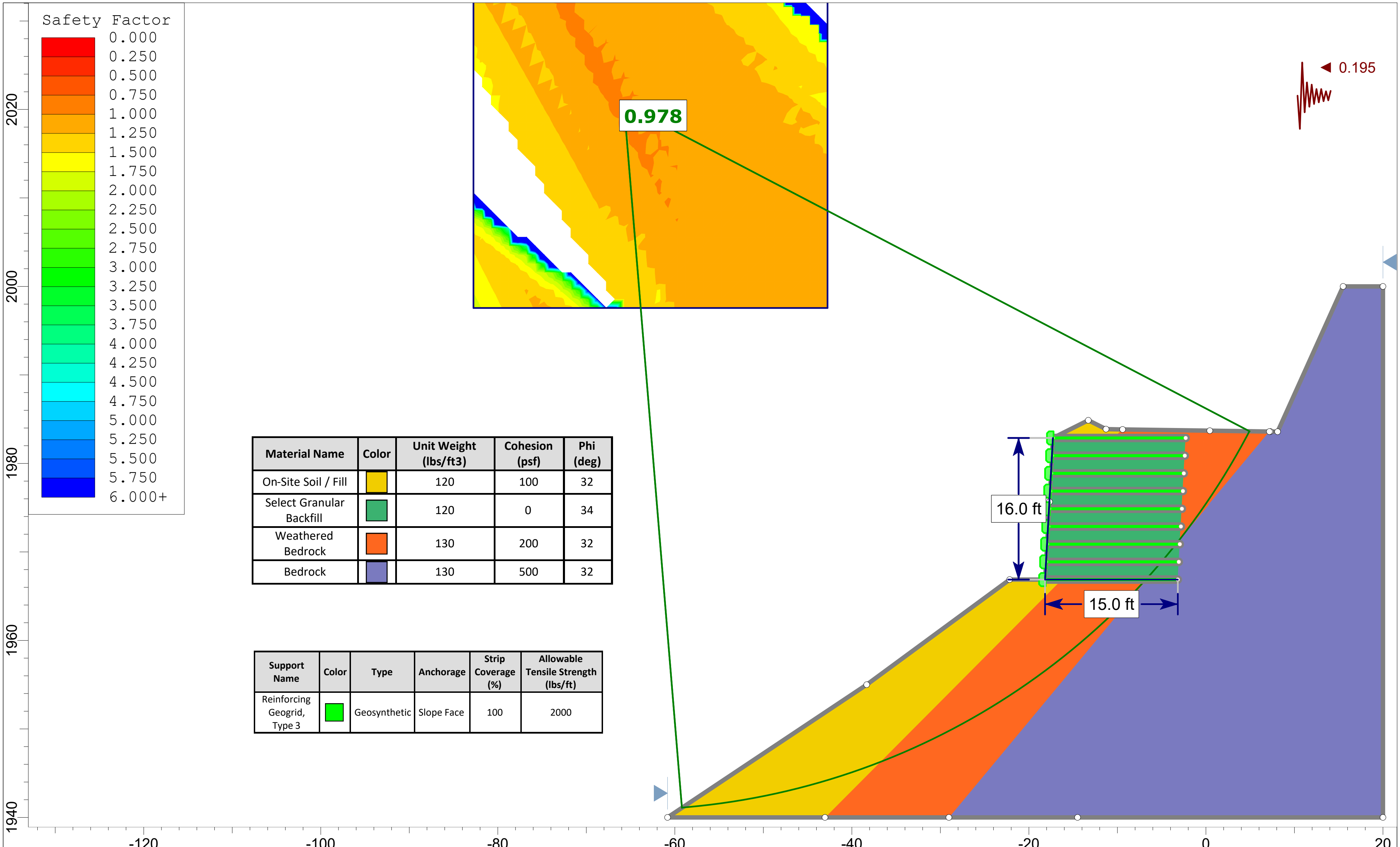
Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	32
Select Granular Backfill		120	0	34
Weathered Bedrock		130	200	32
Bedrock		130	500	32

Support Name	Color	Type	Anchorage	Strip Coverage (%)	Allowable Tensile Strength (lbs/ft)
Reinforcing Geogrid, Type 3		Geosynthetic	Slope Face	100	2000

U.S. Department of Transportation Federal Highway Administration

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	MSE Wall - FS=1.3	*Scenario*	Static
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 16.slmd

SLIDEINTERPRET 9.019



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
On-Site Soil / Fill		120	100	32
Select Granular Backfill		120	0	34
Weathered Bedrock		130	200	32
Bedrock		130	500	32

Support Name	Color	Type	Anchorage	Strip Coverage (%)	Allowable Tensile Strength (lbs/ft)
Reinforcing Geogrid, Type 3		Geosynthetic	Slope Face	100	2000

U.S. Department of Transportation Federal Highway Administration

SLIDEINTERPRET 9.019

Project	CA ERFO FS LSPDR 2021-1(1) Nacimiento-Fergusson Rd		
Group	MSE Wall - FS=1.3	*Scenario*	Seismic
Drawn By	JMA	*Company*	FHWA-CFL
Date	8/10/2022, 12:35:01 PM	*File Name*	Site 16.slmd

MSE Wall External Stability (MSEW)

U.S. Department of Transportation
Federal Highway Administration

FHWA-NHI-10-024
Nacimiento-Fergusson Road

MSEW(3.0): Update # 14.93

PROJECT IDENTIFICATION

Title:	Nacimiento-Fergusson Road
Project Number:	CA ERFO FS LSPDR 2021-1(1)
Client:	USFS
Designer:	JMA
Station Number:	ALL

Description:

Typical MSE Wall Section, Hmax = 18'

Company's information:

Name: FHWA-CFL
Street: 12300 W. Dakota Ave.

Lakewood, CO 80228
Telephone #: 720-963-3633
Fax #:
E-Mail: james.arthurs@dot.gov

Original file path and name: C:\Users\james.arthurs\Documents\Projects\CA ERFO Nacim.....
.....o Road\MSEW\H=18.BEN
Original date and time of creating this file: Wed Aug 17 07:49:28 2022

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

SOIL DATA

REINFORCED SOIL

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

RETAINED SOIL

Unit weight, γ	120.0 lb/ft ³
Design value of internal angle of friction, ϕ	32.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	120.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{equiv.}$	32.0 °
Equivalent cohesion, $c_{equiv.}$	0.0 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)
Inclination of internal slip plane, ψ = 62.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.3076 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 35.49 N γ= 30.21

SEISMICITY

Maximum ground acceleration coefficient, An = 0.380
Design acceleration coefficient in Internal Stability: Kh = Am = 0.406
Design acceleration coefficient in External Stability: Kh_d = 0.406 => Kh = Am = 0.406

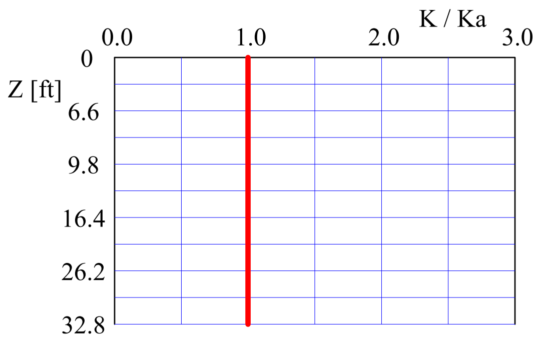
Kae (Kh > 0) = 0.6819 Kae (Kh = 0) = 0.3076 Δ Kae = 0.3743
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

INPUT DATA: Geogrids
(Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	1000.0	1500.0	2000.0	2500.0	3000.0
Durability reduction factor, RFd	1.00	1.00	1.00	1.00	1.00
Installation-damage reduction factor, RFid	1.00	1.00	1.00	1.00	1.00
Creep reduction factor, RFc	1.00	1.00	1.00	1.00	1.00
CDR for strength	N/A	N/A	N/A	N/A	N/A
Coverage ratio, Rc	1.000	1.000	1.000	1.000	1.000
Friction angle along geogrid-soil interface, ρ	24.22	24.22	24.22	24.22	24.22
Pullout resistance factor, F*	0.67·tanϕ	0.67·tanϕ	0.67·tanϕ	0.67·tanϕ	0.67·tanϕ
Scale-effect correction factor, α	0.8	0.8	0.8	0.8	0.8

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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

Design height, Hd	18.00	[ft]	{ Embedded depth is E = 1.50 ft, and height above top of finished bottom grade is H = 16.50 ft }
Batter, ω	0.0	[deg]	
Backslope, β	26.0	[deg]	
Backslope rise	1.0	[ft]	Broken back equivalent angle, I = 1.59° (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 2007-2010 (LRFD) Input Data

INTERNAL STABILITY

Load factor for vertical earth pressure, EV, from Table 3.4.1-2:	$\gamma_{p\text{-}EV}$	1.35	
Load factor for earthquake loads, EQ, from Table 3.4.1-1:	$\gamma_{p\text{-}EQ}$	1.00	
Load factor for live load surchrge, LS, from Figure C11.5.5-3(b): (Same as in External Stability).	$\gamma_{p\text{-}LS}$	1.75	
Load factor for dead load surchrge, ES: (Same as in External Stability).	$\gamma_{p\text{-}ES}$	1.50	
Resistance factor for reinforcement tension from Table 11.5.6-1:	ϕ	Static	Combined static/seismic
Geogrid:		0.90	1.20
Resistance factor for reinforcement tension in connectors from Table 11.5.6-1:	ϕ	Static	Combined static/seismic
Geogrid:		0.90	1.20
Resistance factor for reinforcement pullout from Table 11.5.6-1:	ϕ	0.90	1.20

EXTERNAL STABILITY

Load factor for vertical earth pressure, EV, from Table 3.4.1-2 and Figure C11.5.5-2:		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, from Table 3.4.1-2 and Figure C11.5.5-2:	$\gamma_{p\text{-}EH}$	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, from Table 3.4.1-1 (multiplies P_{AE} and P_{IR}):	$\gamma_{p\text{-}EQ}$	1.00

Resistance factor for shear resistance along common interfaces from Table 11.5.6-1:		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 from Table 11.5.6-1:		Static	Combined Static/Seismic
	ϕ_b	0.65	0.65

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 4.09, factored bearing load = 4291 lb/ft².

Foundation Interface: Direct sliding, CDR = 2.081, Eccentricity, e/L = 0.1141, CDR-overturning = 4.22

GEOGRID				CONNECTION							
#	Elevation [ft]	Length [ft]	Type #	CDR [pullout resistance]	CDR [connection break]	CDR [geogrid strength]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.00	17.50	4	N/A	N/A	N/A	2.245	26.778	1.498	0.1141	Type 4
2	2.00	17.50	4	N/A	N/A	N/A	1.209	12.144	1.634	0.0937	Type 4
3	4.00	17.50	3	N/A	N/A	N/A	1.077	11.176	1.796	0.0750	Type 3
4	6.00	17.50	3	N/A	N/A	N/A	1.216	10.175	1.995	0.0582	Type 3
5	8.00	17.50	3	N/A	N/A	N/A	1.396	9.149	2.243	0.0432	Type 3
6	10.00	17.50	2	N/A	N/A	N/A	1.229	8.081	2.562	0.0299	Type 2
7	12.00	17.50	2	N/A	N/A	N/A	1.488	6.943	2.986	0.0182	Type 2
8	14.00	17.50	2	N/A	N/A	N/A	1.884	5.679	3.577	0.0077	Type 2
9	16.00	17.50	2	N/A	N/A	N/A	1.882	3.045	4.448	-0.0030	Type 2

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, CDR = 2.13, factored bearing load = 5957 lb/ft².

Foundation Interface: Direct sliding, CDR = 1.018, Eccentricity, e/L = 0.2948, Fs-overturning = 1.68

GEOGRID				CONNECTION							
#	Elevation [ft]	Length [ft]	Type #	CDR [pullout resistance]	CDR [connection break]	CDR [geogrid strength]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.00	17.50	4	N/A	N/A	N/A	1.754	16.740	0.733	0.2948	Type 4
2	2.00	17.50	4	N/A	N/A	N/A	1.187	9.545	0.809	0.2385	Type 4
3	4.00	17.50	3	N/A	N/A	N/A	1.047	8.688	0.903	0.1879	Type 3
4	6.00	17.50	3	N/A	N/A	N/A	1.166	7.802	1.022	0.1431	Type 3
5	8.00	17.50	3	N/A	N/A	N/A	1.315	6.894	1.178	0.1040	Type 3
6	10.00	17.50	2	N/A	N/A	N/A	1.131	5.950	1.391	0.0706	Type 2
7	12.00	17.50	2	N/A	N/A	N/A	1.326	4.951	1.700	0.0426	Type 2
8	14.00	17.50	2	N/A	N/A	N/A	1.602	3.864	2.192	0.0199	Type 2
9	16.00	17.50	2	N/A	N/A	N/A	1.665	2.155	3.273	-0.0001	Type 2

U.S. Department of Transportation
Federal Highway Administration

FHWA-NHI-10-024
Nacimiento-Fergusson Road

MSEW(3.0): Update # 14.93

PROJECT IDENTIFICATION

Title:	Nacimiento-Fergusson Road
Project Number:	CA ERFO FS LSPDR 2021-1(1)
Client:	USFS
Designer:	JMA
Station Number:	ALL

Description:

Typical MSE Wall Section, Hmax = 16'

Company's information:

Name: FHWA-CFL
Street: 12300 W. Dakota Ave.

Lakewood, CO 80228
Telephone #: 720-963-3633
Fax #:
E-Mail: james.arthurs@dot.gov

Original file path and name: C:\Users\james.arthurs\Documents\Projects\CA ERFO Nacim.....
.....o Road\MSEW\H=16.BEN
Original date and time of creating this file: Wed Aug 17 07:49:28 2022

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

SOIL DATA

REINFORCED SOIL

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

RETAINED SOIL

Unit weight, γ	120.0 lb/ft ³
Design value of internal angle of friction, ϕ	32.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	120.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{equiv.}$	32.0 °
Equivalent cohesion, $c_{equiv.}$	0.0 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)
Inclination of internal slip plane, ψ = 62.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.3077 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 35.49 N_γ = 30.21

SEISMICITY

Maximum ground acceleration coefficient, An = 0.380
Design acceleration coefficient in Internal Stability: Kh = Am = 0.406
Design acceleration coefficient in External Stability: Kh_d = 0.406 => Kh = Am = 0.406

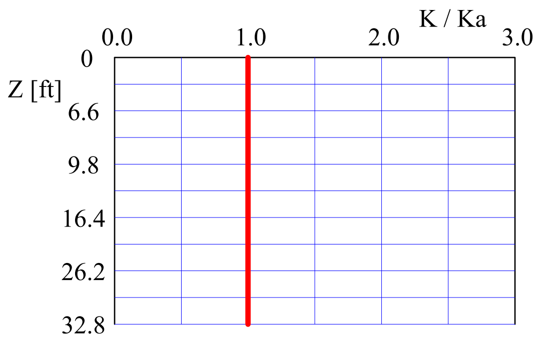
Kae (Kh > 0) = 0.6857 Kae (Kh = 0) = 0.3077 Δ Kae = 0.3780
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

INPUT DATA: Geogrids
(Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	1000.0	1500.0	2000.0	2500.0	3000.0
Durability reduction factor, RFd	1.00	1.00	1.00	1.00	1.00
Installation-damage reduction factor, RFid	1.00	1.00	1.00	1.00	1.00
Creep reduction factor, RFc	1.00	1.00	1.00	1.00	1.00
CDR for strength	N/A	N/A	N/A	N/A	N/A
Coverage ratio, Rc	1.000	1.000	1.000	1.000	1.000
Friction angle along geogrid-soil interface, ρ	24.22	24.22	24.22	24.22	24.22
Pullout resistance factor, F*	0.67·tanϕ	0.67·tanϕ	0.67·tanϕ	0.67·tanϕ	0.67·tanϕ
Scale-effect correction factor, α	0.8	0.8	0.8	0.8	0.8

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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

Design height, Hd	16.00	[ft]	{ Embedded depth is E = 1.50 ft, and height above top of finished bottom grade is H = 14.50 ft }
Batter, ω	0.0	[deg]	
Backslope, β	26.0	[deg]	
Backslope rise	1.0	[ft]	Broken back equivalent angle, I = 1.79° (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 2007-2010 (LRFD) Input Data

INTERNAL STABILITY

Load factor for vertical earth pressure, EV, from Table 3.4.1-2:	$\gamma_{p\text{-}EV}$	1.35	
Load factor for earthquake loads, EQ, from Table 3.4.1-1:	$\gamma_{p\text{-}EQ}$	1.00	
Load factor for live load surchrge, LS, from Figure C11.5.5-3(b): (Same as in External Stability).	$\gamma_{p\text{-}LS}$	1.75	
Load factor for dead load surchrge, ES: (Same as in External Stability).	$\gamma_{p\text{-}ES}$	1.50	
Resistance factor for reinforcement tension from Table 11.5.6-1:	ϕ	Static	Combined static/seismic
Geogrid:		0.90	1.20
Resistance factor for reinforcement tension in connectors from Table 11.5.6-1:	ϕ	Static	Combined static/seismic
Geogrid:		0.90	1.20
Resistance factor for reinforcement pullout from Table 11.5.6-1:	ϕ	0.90	1.20

EXTERNAL STABILITY

Load factor for vertical earth pressure, EV, from Table 3.4.1-2 and Figure C11.5.5-2:		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, from Table 3.4.1-2 and Figure C11.5.5-2:	$\gamma_{p\text{-}EH}$	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, from Table 3.4.1-1 (multiplies P_{AE} and P_{IR}):	$\gamma_{p\text{-}EQ}$	1.00

Resistance factor for shear resistance along common interfaces from Table 11.5.6-1:		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 from Table 11.5.6-1:		Static	Combined Static/Seismic
	ϕ_b	0.65	0.65

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 4.17, factored bearing load = 3871 lb/ft².

Foundation Interface: Direct sliding, CDR = 2.077, Eccentricity, e/L = 0.1120, CDR-overturning = 4.28

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [pullout resistance]	CDR [connection break]	CDR [geogrid strength]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.00	16.00	3	N/A	N/A	N/A	1.986	24.200	1.496	0.1120	Type 3
2	2.00	16.00	3	N/A	N/A	N/A	1.078	10.853	1.644	0.0898	Type 3
3	4.00	16.00	3	N/A	N/A	N/A	1.217	9.872	1.825	0.0697	Type 3
4	6.00	16.00	2	N/A	N/A	N/A	1.048	8.855	2.052	0.0519	Type 2
5	8.00	16.00	2	N/A	N/A	N/A	1.230	7.800	2.343	0.0361	Type 2
6	10.00	16.00	2	N/A	N/A	N/A	1.489	6.678	2.730	0.0222	Type 2
7	12.00	16.00	2	N/A	N/A	N/A	1.886	5.440	3.269	0.0098	Type 2
8	14.00	16.00	2	N/A	N/A	N/A	1.886	2.904	4.061	-0.0026	Type 2

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, CDR = 2.27, factored bearing load = 5256 lb/ft².

Foundation Interface: Direct sliding, CDR = 1.028, Eccentricity, e/L = 0.2852, Fs-overturning = 1.74

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [pullout resistance]	CDR [connection break]	CDR [geogrid strength]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.00	16.00	3	N/A	N/A	N/A	1.565	15.257	0.740	0.2852	Type 3
2	2.00	16.00	3	N/A	N/A	N/A	1.064	8.571	0.826	0.2249	Type 3
3	4.00	16.00	3	N/A	N/A	N/A	1.186	7.699	0.934	0.1713	Type 3
4	6.00	16.00	2	N/A	N/A	N/A	1.005	6.796	1.077	0.1246	Type 2
5	8.00	16.00	2	N/A	N/A	N/A	1.155	5.861	1.271	0.0847	Type 2
6	10.00	16.00	2	N/A	N/A	N/A	1.358	4.873	1.552	0.0515	Type 2
7	12.00	16.00	2	N/A	N/A	N/A	1.647	3.800	2.001	0.0244	Type 2
8	14.00	16.00	2	N/A	N/A	N/A	1.712	2.109	2.986	0.0008	Type 2

U.S. Department of Transportation
Federal Highway Administration

FHWA-NHI-10-024
Nacimiento-Fergusson Road

MSEW(3.0): Update # 14.93

PROJECT IDENTIFICATION

Title:	Nacimiento-Fergusson Road
Project Number:	CA ERFO FS LSPDR 2021-1(1)
Client:	USFS
Designer:	JMA
Station Number:	ALL

Description:

Typical MSE Wall Section, Hmax = 14'

Company's information:

Name: FHWA-CFL
Street: 12300 W. Dakota Ave.

Lakewood, CO 80228
Telephone #: 720-963-3633
Fax #:
E-Mail: james.arthurs@dot.gov

Original file path and name: C:\Users\james.arthurs\Documents\Projects\CA ERFO Nacim.....
.....o Road\MSEW\H=14.BEN

Original date and time of creating this file: Wed Aug 17 07:49:28 2022

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

SOIL DATA

REINFORCED SOIL

Unit weight, γ 125.0 lb/ft ³

Design value of internal angle of friction, ϕ 34.0 °

RETAINED SOIL

Unit weight, γ 120.0 lb/ft ³

Design value of internal angle of friction, ϕ 32.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$ 120.0 lb/ft ³

Equivalent internal angle of friction, $\phi_{equiv.}$ 32.0 °

Equivalent cohesion, $c_{equiv.}$ 0.0 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)
Inclination of internal slip plane, ψ = 62.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.3078 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 35.49 N γ= 30.21

SEISMICITY

Maximum ground acceleration coefficient, An = 0.380
Design acceleration coefficient in Internal Stability: Kh = Am = 0.406
Design acceleration coefficient in External Stability: Kh_d = 0.406 => Kh = Am = 0.406

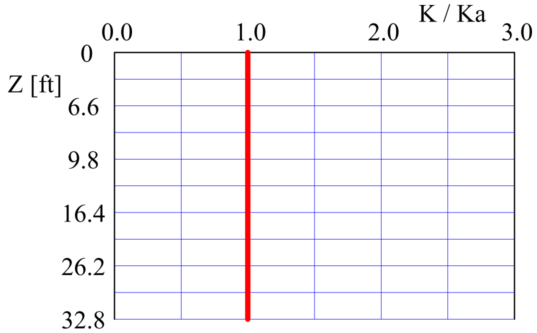
Kae (Kh > 0) = 0.6906 Kae (Kh = 0) = 0.3078 Δ Kae = 0.3828
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

INPUT DATA: Geogrids
(Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	1000.0	1500.0	2000.0	2500.0	3000.0
Durability reduction factor, RFd	1.00	1.00	1.00	1.00	1.00
Installation-damage reduction factor, RFid	1.00	1.00	1.00	1.00	1.00
Creep reduction factor, RFc	1.00	1.00	1.00	1.00	1.00
CDR for strength	N/A	N/A	N/A	N/A	N/A
Coverage ratio, Rc	1.000	1.000	1.000	1.000	1.000
Friction angle along geogrid-soil interface, ρ	24.22	24.22	24.22	24.22	24.22
Pullout resistance factor, F*	0.67·tanϕ	0.67·tanϕ	0.67·tanϕ	0.67·tanϕ	0.67·tanϕ
Scale-effect correction factor, α	0.8	0.8	0.8	0.8	0.8

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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

Design height, Hd	14.00	[ft]	{ Embedded depth is E = 1.50 ft, and height above top of finished bottom grade is H = 12.50 ft }
Batter, ω	0.0	[deg]	
Backslope, β	26.0	[deg]	
Backslope rise	1.0	[ft]	Broken back equivalent angle, I = 2.05° (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 2007-2010 (LRFD) Input Data

INTERNAL STABILITY

Load factor for vertical earth pressure, EV, from Table 3.4.1-2:	$\gamma_{p\text{-}EV}$	1.35	
Load factor for earthquake loads, EQ, from Table 3.4.1-1:	$\gamma_{p\text{-}EQ}$	1.00	
Load factor for live load surchrge, LS, from Figure C11.5.5-3(b): (Same as in External Stability).	$\gamma_{p\text{-}LS}$	1.75	
Load factor for dead load surchrge, ES: (Same as in External Stability).	$\gamma_{p\text{-}ES}$	1.50	
Resistance factor for reinforcement tension from Table 11.5.6-1:	ϕ	Static	Combined static/seismic
Geogrid:		0.90	1.20
Resistance factor for reinforcement tension in connectors from Table 11.5.6-1:	ϕ	Static	Combined static/seismic
Geogrid:		0.90	1.20
Resistance factor for reinforcement pullout from Table 11.5.6-1:	ϕ	0.90	1.20

EXTERNAL STABILITY

Load factor for vertical earth pressure, EV, from Table 3.4.1-2 and Figure C11.5.5-2:

		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, from Table 3.4.1-2 and Figure C11.5.5-2:	$\gamma_{p\text{-}EH}$	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, from Table 3.4.1-1 (multiplies P_{AE} and P_{IR}):	$\gamma_{p\text{-}EQ}$	1.00

Resistance factor for shear resistance along common interfaces from Table 11.5.6-1:

		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 from Table 11.5.6-1:

	Static	Combined Static/Seismic
ϕ_b	0.65	0.65

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 4.02, factored bearing load = 3494 lb/ft².

Foundation Interface: Direct sliding, CDR = 2.001, Eccentricity, e/L = 0.1174, CDR-overturning = 4.06

GEOGRID				CONNECTION							
#	Elevation [ft]	Length [ft]	Type #	CDR [pullout resistance]	CDR [connection break]	CDR [geogrid strength]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.00	14.00	3	N/A	N/A	N/A	2.221	20.881	1.441	0.1174	Type 3
2	2.00	14.00	3	N/A	N/A	N/A	1.218	9.200	1.599	0.0914	Type 3
3	4.00	14.00	2	N/A	N/A	N/A	1.049	8.216	1.797	0.0681	Type 2
4	6.00	14.00	2	N/A	N/A	N/A	1.232	7.185	2.051	0.0477	Type 2
5	8.00	14.00	2	N/A	N/A	N/A	1.491	6.101	2.389	0.0297	Type 2
6	10.00	14.00	2	N/A	N/A	N/A	1.889	4.919	2.858	0.0139	Type 2
7	12.00	14.00	2	N/A	N/A	N/A	1.891	2.592	3.545	-0.0016	Type 2

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, CDR = 2.18, factored bearing load = 4756 lb/ft².

Foundation Interface: Direct sliding, CDR = 1.004, Eccentricity, e/L = 0.2938, Fs-overturning = 1.68

GEOGRID				CONNECTION							
#	Elevation [ft]	Length [ft]	Type #	CDR [pullout resistance]	CDR [connection break]	CDR [geogrid strength]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.00	14.00	3	N/A	N/A	N/A	1.761	13.244	0.723	0.2938	Type 3
2	2.00	14.00	3	N/A	N/A	N/A	1.207	7.293	0.818	0.2241	Type 3
3	4.00	14.00	2	N/A	N/A	N/A	1.025	6.424	0.942	0.1633	Type 2
4	6.00	14.00	2	N/A	N/A	N/A	1.182	5.517	1.111	0.1113	Type 2
5	8.00	14.00	2	N/A	N/A	N/A	1.395	4.567	1.357	0.0680	Type 2
6	10.00	14.00	2	N/A	N/A	N/A	1.703	3.546	1.748	0.0330	Type 2
7	12.00	14.00	2	N/A	N/A	N/A	1.774	1.945	2.605	0.0029	Type 2

U.S. Department of Transportation
Federal Highway Administration

FHWA-NHI-10-024
Nacimiento-Fergusson Road

MSEW(3.0): Update # 14.93

PROJECT IDENTIFICATION

Title:	Nacimiento-Fergusson Road
Project Number:	CA ERFO FS LSPDR 2021-1(1)
Client:	USFS
Designer:	JMA
Station Number:	ALL

Description:

Typical MSE Wall Section, Hmax = 12'

Company's information:

Name: FHWA-CFL
Street: 12300 W. Dakota Ave.

Lakewood, CO 80228
Telephone #: 720-963-3633
Fax #:
E-Mail: james.arthurs@dot.gov

Original file path and name: C:\Users\james.arthurs\Documents\Projects\CA ERFO Nacim.....
.....o Road\MSEW\H=12.BEN

Original date and time of creating this file: Wed Aug 17 07:49:28 2022

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

SOIL DATA

REINFORCED SOIL

Unit weight, γ — 125.0 lb/ft ^{3}

Design value of internal angle of friction, ϕ — 34.0 °

RETAINED SOIL

Unit weight, γ — 120.0 lb/ft ^{3}

Design value of internal angle of friction, ϕ — 32.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$ — 120.0 lb/ft ^{3}

Equivalent internal angle of friction, $\phi_{equiv.}$ — 32.0 °

Equivalent cohesion, $c_{equiv.}$ — 0.0 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)
Inclination of internal slip plane, ψ = 62.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.3080 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 35.49 N γ= 30.21

SEISMICITY

Maximum ground acceleration coefficient, An = 0.380
Design acceleration coefficient in Internal Stability: Kh = Am = 0.406
Design acceleration coefficient in External Stability: Kh_d = 0.406 => Kh = Am = 0.406

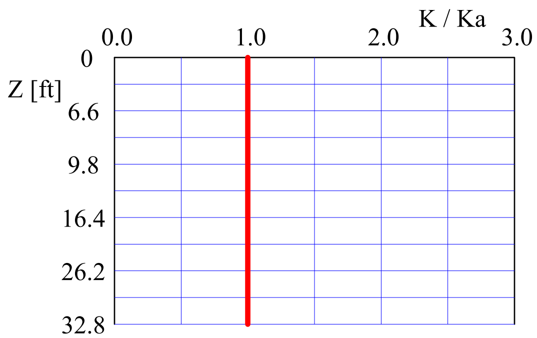
Kae (Kh > 0) = 0.6975 Kae (Kh = 0) = 0.3080 Δ Kae = 0.3895
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

INPUT DATA: Geogrids
(Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	1000.0	1500.0	2000.0	2500.0	3000.0
Durability reduction factor, RFd	1.00	1.00	1.00	1.00	1.00
Installation-damage reduction factor, RFid	1.00	1.00	1.00	1.00	1.00
Creep reduction factor, RFc	1.00	1.00	1.00	1.00	1.00
CDR for strength	N/A	N/A	N/A	N/A	N/A
Coverage ratio, Rc	1.000	1.000	1.000	1.000	1.000
Friction angle along geogrid-soil interface, ρ	24.22	24.22	24.22	24.22	24.22
Pullout resistance factor, F*	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$
Scale-effect correction factor, α	0.8	0.8	0.8	0.8	0.8

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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

Design height, Hd	12.00	[ft]	{ Embedded depth is E = 1.50 ft, and height above top of finished bottom grade is H = 10.50 ft }
Batter, ω	0.0	[deg]	
Backslope, β	26.0	[deg]	
Backslope rise	1.0	[ft]	Broken back equivalent angle, I = 2.39° (see Fig. 25 in DEMO 82)

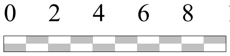
U N I F O R M S U R C H A R G E

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 2007-2010 (LRFD) Input Data

INTERNAL STABILITY

Load factor for vertical earth pressure, EV, from Table 3.4.1-2:	$\gamma_{p\text{-}EV}$	1.35	
Load factor for earthquake loads, EQ, from Table 3.4.1-1:	$\gamma_{p\text{-}EQ}$	1.00	
Load factor for live load surchrge, LS, from Figure C11.5.5-3(b): (Same as in External Stability).	$\gamma_{p\text{-}LS}$	1.75	
Load factor for dead load surchrge, ES: (Same as in External Stability).	$\gamma_{p\text{-}ES}$	1.50	
Resistance factor for reinforcement tension from Table 11.5.6-1:	ϕ	Static	Combined static/seismic
Geogrid:		0.90	1.20
Resistance factor for reinforcement tension in connectors from Table 11.5.6-1:	ϕ	Static	Combined static/seismic
Geogrid:		0.90	1.20
Resistance factor for reinforcement pullout from Table 11.5.6-1:	ϕ	0.90	1.20

EXTERNAL STABILITY

Load factor for vertical earth pressure, EV, from Table 3.4.1-2 and Figure C11.5.5-2:		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, from Table 3.4.1-2 and Figure C11.5.5-2:	$\gamma_{p\text{-}EH}$	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, from Table 3.4.1-1 (multiplies P_{AE} and P_{IR}):	$\gamma_{p\text{-}EQ}$	1.00

Resistance factor for shear resistance along common interfaces from Table 11.5.6-1:		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 from Table 11.5.6-1:		Static	Combined Static/Seismic
	ϕ_b	0.65	0.65

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 4.12, factored bearing load = 3071 lb/ft².

Foundation Interface: Direct sliding, CDR = 1.987, Eccentricity, e/L = 0.1145, CDR-overturning = 4.11

GEOGRID				CONNECTION							
#	Elevation [ft]	Length [ft]	Type #	CDR [pullout resistance]	CDR [connection break]	CDR [geogrid strength]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.00	12.50	2	N/A	N/A	N/A	1.890	18.307	1.431	0.1145	Type 2
2	2.00	12.50	2	N/A	N/A	N/A	1.050	7.909	1.607	0.0856	Type 2
3	4.00	12.50	2	N/A	N/A	N/A	1.233	6.907	1.833	0.0601	Type 2
4	6.00	12.50	2	N/A	N/A	N/A	1.494	5.839	2.134	0.0378	Type 2
5	8.00	12.50	2	N/A	N/A	N/A	1.894	4.684	2.550	0.0183	Type 2
6	10.00	12.50	2	N/A	N/A	N/A	1.898	2.452	3.159	-0.0005	Type 2

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, CDR = 2.36, factored bearing load = 4062 lb/ft².

Foundation Interface: Direct sliding, CDR = 1.015, Eccentricity, e/L = 0.2811, Fs-overturning = 1.75

GEOGRID				CONNECTION							
#	Elevation [ft]	Length [ft]	Type #	CDR [pullout resistance]	CDR [connection break]	CDR [geogrid strength]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.00	12.50	2	N/A	N/A	N/A	1.517	11.757	0.731	0.2811	Type 2
2	2.00	12.50	2	N/A	N/A	N/A	1.048	6.315	0.841	0.2051	Type 2
3	4.00	12.50	2	N/A	N/A	N/A	1.211	5.426	0.992	0.1401	Type 2
4	6.00	12.50	2	N/A	N/A	N/A	1.434	4.483	1.210	0.0860	Type 2
5	8.00	12.50	2	N/A	N/A	N/A	1.757	3.477	1.557	0.0424	Type 2
6	10.00	12.50	2	N/A	N/A	N/A	1.832	1.894	2.318	0.0052	Type 2

U.S. Department of Transportation
Federal Highway Administration

FHWA-NHI-10-024
Nacimiento-Fergusson Road

MSEW(3.0): Update # 14.93

PROJECT IDENTIFICATION

Title:	Nacimiento-Fergusson Road
Project Number:	CA ERFO FS LSPDR 2021-1(1)
Client:	USFS
Designer:	JMA
Station Number:	ALL

Description:

Typical MSE Wall Section, Hmax = 10'

Company's information:

Name: FHWA-CFL
Street: 12300 W. Dakota Ave.

Lakewood, CO 80228
Telephone #: 720-963-3633
Fax #:
E-Mail: james.arthurs@dot.gov

Original file path and name: C:\Users\james.arthurs\Documents\Projects\CA ERFO Nacim.....
.....o Road\MSEW\H=10.BEN

Original date and time of creating this file: Wed Aug 17 07:49:28 2022

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

SOIL DATA

REINFORCED SOIL

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

RETAINED SOIL

Unit weight, γ	120.0 lb/ft ³
Design value of internal angle of friction, ϕ	32.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	120.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{equiv.}$	32.0 °
Equivalent cohesion, $c_{equiv.}$	0.0 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)
Inclination of internal slip plane, ψ = 62.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.3083 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 35.49 N γ= 30.21

SEISMICITY

Maximum ground acceleration coefficient, An = 0.380
Design acceleration coefficient in Internal Stability: Kh = Am = 0.406
Design acceleration coefficient in External Stability: Kh_d = 0.406 => Kh = Am = 0.406

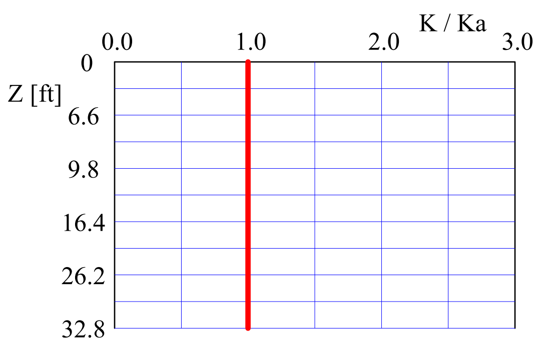
Kae (Kh > 0) = 0.7078 Kae (Kh = 0) = 0.3083 Δ Kae = 0.3994
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

INPUT DATA: Geogrids
(Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	1000.0	1500.0	2000.0	2500.0	3000.0
Durability reduction factor, RFd	1.00	1.00	1.00	1.00	1.00
Installation-damage reduction factor, RFid	1.00	1.00	1.00	1.00	1.00
Creep reduction factor, RFc	1.00	1.00	1.00	1.00	1.00
CDR for strength	N/A	N/A	N/A	N/A	N/A
Coverage ratio, Rc	1.000	1.000	1.000	1.000	1.000
Friction angle along geogrid-soil interface, ρ	24.22	24.22	24.22	24.22	24.22
Pullout resistance factor, F*	0.67·tanφ	0.67·tanφ	0.67·tanφ	0.67·tanφ	0.67·tanφ
Scale-effect correction factor, α	0.8	0.8	0.8	0.8	0.8

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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

Design height, Hd	10.00	[ft]	{ Embedded depth is E = 1.50 ft, and height above top of finished bottom grade is H = 8.50 ft }
Batter, ω	0.0	[deg]	
Backslope, β	26.0	[deg]	
Backslope rise	1.0	[ft]	Broken back equivalent angle, I = 2.86° (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 2007-2010 (LRFD) Input Data

INTERNAL STABILITY

Load factor for vertical earth pressure, EV, from Table 3.4.1-2:	$\gamma_{p\text{-}EV}$	1.35	
Load factor for earthquake loads, EQ, from Table 3.4.1-1:	$\gamma_{p\text{-}EQ}$	1.00	
Load factor for live load surchrge, LS, from Figure C11.5.5-3(b): (Same as in External Stability).	$\gamma_{p\text{-}LS}$	1.75	
Load factor for dead load surchrge, ES: (Same as in External Stability).	$\gamma_{p\text{-}ES}$	1.50	
Resistance factor for reinforcement tension from Table 11.5.6-1:	ϕ	Static	Combined static/seismic
Geogrid:		0.90	1.20
Resistance factor for reinforcement tension in connectors from Table 11.5.6-1:	ϕ	Static	Combined static/seismic
Geogrid:		0.90	1.20
Resistance factor for reinforcement pullout from Table 11.5.6-1:	ϕ	0.90	1.20

EXTERNAL STABILITY

Load factor for vertical earth pressure, EV, from Table 3.4.1-2 and Figure C11.5.5-2:		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, from Table 3.4.1-2 and Figure C11.5.5-2:	$\gamma_{p\text{-}EH}$	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, from Table 3.4.1-1 (multiplies P_{AE} and P_{IR}):	$\gamma_{p\text{-}EQ}$	1.00

Resistance factor for shear resistance along common interfaces from Table 11.5.6-1:		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 from Table 11.5.6-1:		Static	Combined Static/Seismic
	ϕ_b	0.65	0.65

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 4.25, factored bearing load = 2648 lb/ft².

Foundation Interface: Direct sliding, CDR = 1.969, Eccentricity, e/L = 0.1104, CDR-overturning = 4.19

GEOGRID				CONNECTION							
#	Elevation [ft]	Length [ft]	Type #	CDR [pullout resistance]	CDR [connection break]	CDR [geogrid strength]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.00	11.00	2	N/A	N/A	N/A	2.186	15.726	1.418	0.1104	Type 2
2	2.00	11.00	2	N/A	N/A	N/A	1.236	6.612	1.616	0.0778	Type 2
3	4.00	11.00	2	N/A	N/A	N/A	1.498	5.580	1.879	0.0494	Type 2
4	6.00	11.00	2	N/A	N/A	N/A	1.900	4.451	2.244	0.0246	Type 2
5	8.00	11.00	2	N/A	N/A	N/A	1.907	2.314	2.774	0.0013	Type 2

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, CDR = 2.61, factored bearing load = 3388 lb/ft².

Foundation Interface: Direct sliding, CDR = 1.028, Eccentricity, e/L = 0.2650, Fs-overturning = 1.85

GEOGRID				CONNECTION							
#	Elevation [ft]	Length [ft]	Type #	CDR [pullout resistance]	CDR [connection break]	CDR [geogrid strength]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.00	11.00	2	N/A	N/A	N/A	1.782	10.259	0.740	0.2650	Type 2
2	2.00	11.00	2	N/A	N/A	N/A	1.244	5.325	0.872	0.1815	Type 2
3	4.00	11.00	2	N/A	N/A	N/A	1.478	4.405	1.063	0.1120	Type 2
4	6.00	11.00	2	N/A	N/A	N/A	1.820	3.411	1.367	0.0560	Type 2
5	8.00	11.00	2	N/A	N/A	N/A	1.898	1.843	2.031	0.0088	Type 2

U.S. Department of Transportation
Federal Highway Administration

FHWA-NHI-10-024
Nacimiento-Fergusson Road

MSEW(3.0): Update # 14.93

PROJECT IDENTIFICATION

Title:	Nacimiento-Fergusson Road
Project Number:	CA ERFO FS LSPDR 2021-1(1)
Client:	USFS
Designer:	JMA
Station Number:	ALL

Description:

Typical MSE Wall Section, Hmax = 8'

Company's information:

Name: FHWA-CFL
Street: 12300 W. Dakota Ave.

Lakewood, CO 80228
Telephone #: 720-963-3633
Fax #:
E-Mail: james.arthurs@dot.gov

Original file path and name: C:\Users\james.arthurs\Documents\Projects\CA ERFO Nacim.....
.....to Road\MSEW\H=8.BEN

Original date and time of creating this file: Wed Aug 17 07:49:28 2022

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

SOIL DATA

REINFORCED SOIL

Unit weight, γ 125.0 lb/ft ³

Design value of internal angle of friction, ϕ 34.0 °

RETAINED SOIL

Unit weight, γ 120.0 lb/ft ³

Design value of internal angle of friction, ϕ 32.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$ 120.0 lb/ft ³

Equivalent internal angle of friction, $\phi_{equiv.}$ 32.0 °

Equivalent cohesion, $c_{equiv.}$ 0.0 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)
Inclination of internal slip plane, ψ = 62.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.3089 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 35.49 N γ= 30.21

SEISMICITY

Maximum ground acceleration coefficient, An = 0.380
Design acceleration coefficient in Internal Stability: Kh = Am = 0.406
Design acceleration coefficient in External Stability: Kh_d = 0.406 => Kh = Am = 0.406

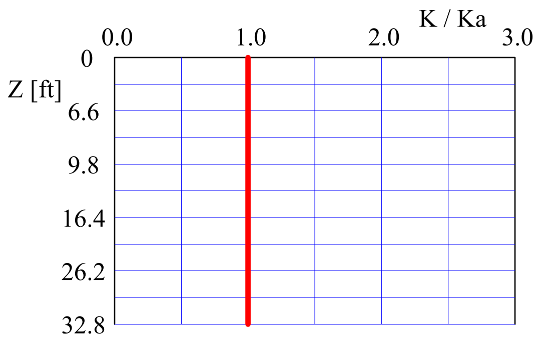
Kae (Kh > 0) = 0.7246 Kae (Kh = 0) = 0.3089 Δ Kae = 0.4157
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

INPUT DATA: Geogrids
(Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	1000.0	1500.0	2000.0	2500.0	3000.0
Durability reduction factor, RFd	1.00	1.00	1.00	1.00	1.00
Installation-damage reduction factor, RFid	1.00	1.00	1.00	1.00	1.00
Creep reduction factor, RFc	1.00	1.00	1.00	1.00	1.00
CDR for strength	N/A	N/A	N/A	N/A	N/A
Coverage ratio, Rc	1.000	1.000	1.000	1.000	1.000
Friction angle along geogrid-soil interface, ρ	24.22	24.22	24.22	24.22	24.22
Pullout resistance factor, F*	0.67·tanϕ	0.67·tanϕ	0.67·tanϕ	0.67·tanϕ	0.67·tanϕ
Scale-effect correction factor, α	0.8	0.8	0.8	0.8	0.8

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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

Design height, Hd	8.00	[ft]	{ Embedded depth is E = 1.50 ft, and height above top of finished bottom grade is H = 6.50 ft }
Batter, ω	0.0	[deg]	
Backslope, β	26.0	[deg]	
Backslope rise	1.0	[ft]	Broken back equivalent angle, I = 3.58° (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:

AASHTO 2007-2010 (LRFD) Input Data

INTERNAL STABILITY

Load factor for vertical earth pressure, EV, from Table 3.4.1-2:	$\gamma_{p\text{-}EV}$	1.35	
Load factor for earthquake loads, EQ, from Table 3.4.1-1:	$\gamma_{p\text{-}EQ}$	1.00	
Load factor for live load surchrge, LS, from Figure C11.5.5-3(b): (Same as in External Stability).	$\gamma_{p\text{-}LS}$	1.75	
Load factor for dead load surchrge, ES: (Same as in External Stability).	$\gamma_{p\text{-}ES}$	1.50	
Resistance factor for reinforcement tension from Table 11.5.6-1:	ϕ	Static	Combined static/seismic
Geogrid:		0.90	1.20
Resistance factor for reinforcement tension in connectors from Table 11.5.6-1:	ϕ	Static	Combined static/seismic
Geogrid:		0.90	1.20
Resistance factor for reinforcement pullout from Table 11.5.6-1:	ϕ	0.90	1.20

EXTERNAL STABILITY

Load factor for vertical earth pressure, EV, from Table 3.4.1-2 and Figure C11.5.5-2:		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, from Table 3.4.1-2 and Figure C11.5.5-2:	$\gamma_{p\text{-}EH}$	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, from Table 3.4.1-1 (multiplies P_{AE} and P_{IR}):	$\gamma_{p\text{-}EQ}$	1.00

Resistance factor for shear resistance along common interfaces from Table 11.5.6-1:		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 from Table 11.5.6-1:		Static	Combined Static/Seismic
	ϕ_b	0.65	0.65

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 4.44, factored bearing load = 2224 lb/ft².

Foundation Interface: Direct sliding, CDR = 1.945, Eccentricity, e/L = 0.1041, CDR-overturning = 4.32

GEOGRID				CONNECTION							
#	Elevation [ft]	Length [ft]	Type #	CDR [pullout resistance]	CDR [connection break]	CDR [geogrid strength]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.00	9.50	2	N/A	N/A	N/A	2.594	13.140	1.400	0.1041	Type 2
2	2.00	9.50	2	N/A	N/A	N/A	1.504	5.304	1.626	0.0666	Type 2
3	4.00	9.50	2	N/A	N/A	N/A	1.910	4.222	1.938	0.0342	Type 2
4	6.00	9.50	2	N/A	N/A	N/A	1.921	2.181	2.389	0.0043	Type 2

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, CDR = 2.94, factored bearing load = 2740 lb/ft².

Foundation Interface: Direct sliding, CDR = 1.046, Eccentricity, e/L = 0.2438, Fs-overturning = 1.99

GEOGRID				CONNECTION							
#	Elevation [ft]	Length [ft]	Type #	CDR [pullout resistance]	CDR [connection break]	CDR [geogrid strength]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.00	9.50	2	N/A	N/A	N/A	2.160	8.753	0.753	0.2438	Type 2
2	2.00	9.50	2	N/A	N/A	N/A	1.531	4.320	0.917	0.1512	Type 2
3	4.00	9.50	2	N/A	N/A	N/A	1.895	3.352	1.176	0.0767	Type 2
4	6.00	9.50	2	N/A	N/A	N/A	1.977	1.795	1.745	0.0145	Type 2

U.S. Department of Transportation
Federal Highway Administration

FHWA-NHI-10-024
Nacimiento-Fergusson Road

MSEW(3.0): Update # 14.93

PROJECT IDENTIFICATION

Title:	Nacimiento-Fergusson Road
Project Number:	CA ERFO FS LSPDR 2021-1(1)
Client:	USFS
Designer:	JMA
Station Number:	ALL

Description:

Typical MSE Wall Section, Hmax = 6'

Company's information:

Name: FHWA-CFL
Street: 12300 W. Dakota Ave.

Lakewood, CO 80228
Telephone #: 720-963-3633
Fax #:
E-Mail: james.arthurs@dot.gov

Original file path and name: C:\Users\james.arthurs\Documents\Projects\CA ERFO Nacim.....
.....to Road\MSEW\H=6.BEN

Original date and time of creating this file: Wed Aug 17 07:49:28 2022

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

SOIL DATA

REINFORCED SOIL

Unit weight, γ 125.0 lb/ft ^{3}

Design value of internal angle of friction, ϕ 34.0 °

RETAINED SOIL

Unit weight, γ 120.0 lb/ft ^{3}

Design value of internal angle of friction, ϕ 32.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$ 120.0 lb/ft ^{3}

Equivalent internal angle of friction, $\phi_{equiv.}$ 32.0 °

Equivalent cohesion, $c_{equiv.}$ 0.0 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)
Inclination of internal slip plane, ψ = 62.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.3102 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): Nc = 35.49 N γ= 30.21

SEISMICITY

Maximum ground acceleration coefficient, An = 0.380
Design acceleration coefficient in Internal Stability: Kh = Am = 0.406
Design acceleration coefficient in External Stability: Kh_d = 0.406 => Kh = Am = 0.406

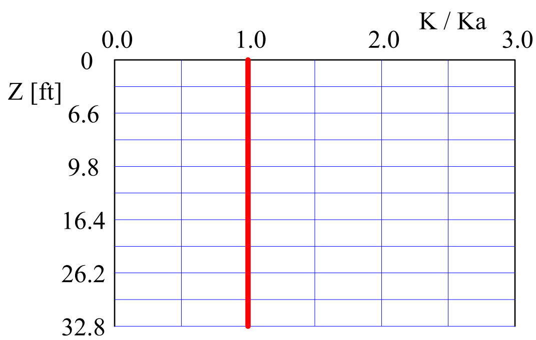
Kae (Kh > 0) = 0.7575 Kae (Kh = 0) = 0.3102 Δ Kae = 0.4473
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

INPUT DATA: Geogrids
(Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	1000.0	1500.0	2000.0	2500.0	3000.0
Durability reduction factor, RFd	1.00	1.00	1.00	1.00	1.00
Installation-damage reduction factor, RFid	1.00	1.00	1.00	1.00	1.00
Creep reduction factor, RFc	1.00	1.00	1.00	1.00	1.00
CDR for strength	N/A	N/A	N/A	N/A	N/A
Coverage ratio, Rc	1.000	1.000	1.000	1.000	1.000
Friction angle along geogrid-soil interface, ρ	24.22	24.22	24.22	24.22	24.22
Pullout resistance factor, F*	0.67·tanφ	0.67·tanφ	0.67·tanφ	0.67·tanφ	0.67·tanφ
Scale-effect correction factor, α	0.8	0.8	0.8	0.8	0.8

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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

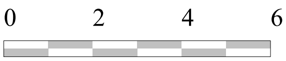
Design height, Hd	6.00	[ft]	{ Embedded depth is E = 1.50 ft, and height above top of finished bottom grade is H = 4.50 ft }
Batter, ω	0.0	[deg]	
Backslope, β	26.0	[deg]	
Backslope rise	1.0	[ft]	Broken back equivalent angle, I = 4.76° (see Fig. 25 in DEMO 82)

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:



AASHTO 2007-2010 (LRFD) Input Data

INTERNAL STABILITY

Load factor for vertical earth pressure, EV, from Table 3.4.1-2:	$\gamma_{p\text{-}EV}$	1.35	
Load factor for earthquake loads, EQ, from Table 3.4.1-1:	$\gamma_{p\text{-}EQ}$	1.00	
Load factor for live load surchrge, LS, from Figure C11.5.5-3(b): (Same as in External Stability).	$\gamma_{p\text{-}LS}$	1.75	
Load factor for dead load surchrge, ES: (Same as in External Stability).	$\gamma_{p\text{-}ES}$	1.50	
Resistance factor for reinforcement tension from Table 11.5.6-1:	ϕ	Static	Combined static/seismic
Geogrid:		0.90	1.20
Resistance factor for reinforcement tension in connectors from Table 11.5.6-1:	ϕ	Static	Combined static/seismic
Geogrid:		0.90	1.20
Resistance factor for reinforcement pullout from Table 11.5.6-1:	ϕ	0.90	1.20

EXTERNAL STABILITY

Load factor for vertical earth pressure, EV, from Table 3.4.1-2 and Figure C11.5.5-2:		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, from Table 3.4.1-2 and Figure C11.5.5-2:	$\gamma_{p\text{-}EH}$	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, from Table 3.4.1-1 (multiplies P_{AE} and P_{IR}):	$\gamma_{p\text{-}EQ}$	1.00

Resistance factor for shear resistance along common interfaces from Table 11.5.6-1:		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 from Table 11.5.6-1:		Static	Combined Static/Seismic
	ϕ_b	0.65	0.65

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 4.72, factored bearing load = 1800 lb/ft².

Foundation Interface: Direct sliding, CDR = 1.911, Eccentricity, e/L = 0.0938, CDR-overturning = 4.53

GEOGRID				CONNECTION							
#	Elevation [ft]	Length [ft]	Type #	CDR [pullout resistance]	CDR [connection break]	CDR [geogrid strength]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.00	8.00	2	N/A	N/A	N/A	3.198	10.544	1.376	0.0938	Type 2
2	2.00	8.00	2	N/A	N/A	N/A	1.925	3.978	1.635	0.0493	Type 2
3	4.00	8.00	2	N/A	N/A	N/A	1.945	2.056	2.006	0.0092	Type 2

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, CDR = 3.41, factored bearing load = 2123 lb/ft².

Foundation Interface: Direct sliding, CDR = 1.070, Eccentricity, e/L = 0.2145, Fs-overturning = 2.22

GEOGRID				CONNECTION							
#	Elevation [ft]	Length [ft]	Type #	CDR [pullout resistance]	CDR [connection break]	CDR [geogrid strength]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.00	8.00	2	N/A	N/A	N/A	2.742	7.232	0.770	0.2145	Type 2
2	2.00	8.00	2	N/A	N/A	N/A	1.990	3.290	0.985	0.1105	Type 2
3	4.00	8.00	2	N/A	N/A	N/A	2.079	1.757	1.457	0.0242	Type 2