



Final Structure Foundation Exploration Report

HAM-126-19.50

Hamilton County, OH
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EXECUTIVE SUMMARY

This report summarizes the results of the structure foundation exploration program performed in support of the replacement of Bridge No. HAM 00126 19500 (SFN 3118991) carrying a pedestrian crosswalk over State Route 126 (Ronald Reagan Cross County Highway) in Hamilton County, Ohio near the border of the City of Blue Ash and the City of Montgomery. The bridge abutments will be supported by pre-bored piles socketed into the underlying bedrock. The ramps leading up to each respective bridge abutment will be supported by Mechanically Stabilized Earth (MSE) Walls identified as Wall 001 (Rear Abutment) and Wall 002 (Forward Abutment).

The report includes the geotechnical information obtained from the borings and laboratory testing performed under this study. The exploration findings, along with the laboratory test results, are presented in more detail in Section 3, as well as in Appendices C and D.

Based on HDR's assessment of the borings, the generalized soil profile consists of an overlying layer of cohesive soil underlain by bedrock consisting of interbedded shale and limestone. Further discussion on the encountered subsurface conditions is included in Section 4.

Specific recommendations related to the proposed bridge foundations and MSE walls can be found in Section 6 of this report, with discussion on the analyses presented in Section 5. The analyses themselves are located in Appendix E.

1 INTRODUCTION

This report summarizes the results of the structure foundation exploration program performed in support of the replacement of Bridge No. HAM 00126 19500 (SFN 3118991) in Hamilton County, Ohio along the border of the cities of Montgomery and Blue Ash. This pedestrian bridge spans over State Route 126/Ronald Reagan Cross County Highway (SR 126) connecting Donjoy Drive to Sycamore Junior High School. The project site is located approximately 0.4 miles east of Kenwood Road and roughly 0.2 miles west of Interstate 71 as shown on the Site Vicinity Map (Exhibit No. 1) in Appendix A. The work includes the complete removal of the existing 202-foot pedestrian bridge structure and its replacement with a 143-foot single-span, twin steel plate girder bridge with reinforced concrete deck and approach slabs at each abutment based on information provided in the Stage 1 plan set dated September 20, 2024.

This geotechnical study was authorized by the Ohio Department of Transportation (ODOT) on June 11, 2024 under Agreement No. 38136. The geotechnical services performed under this agreement were conducted in general accordance with ODOT's Specifications for Geotechnical Explorations (SGE), Geotechnical Design Manual (GDM), Bridge Design Manual (BDM), and the Location and Design Manual, Volume 2. All four documents are dated July 2024. The scope of work relative to this exploration report included:

- A literature search and field reconnaissance of the project site,
- review of available soil and geologic information within the project area,
- the development and performance of a subsurface exploration program to evaluate the existing subsurface conditions at the project location,
- laboratory testing on selected soil and rock samples in accordance with the requirements of the SGE,
- characterization of a generalized soil and rock profile along with recommended design strength parameters,
- foundation design for the bridge substructure units,
- external stability for the Mechanically Stabilized Earth (MSE) walls forming the access ramps, and
- preparation of this Structure Foundation Exploration report.

This report presents the descriptions and interpretations of the encountered subsurface conditions at the site and provides general geotechnical recommendations to assist in the development of the plans and design of the bridge and walls by HDR's Bridge Division.

2 GEOLOGY AND OBSERVATIONS

2.1 Project Setting

This project is located within the northeast region of Hamilton County, Ohio in an urban setting surrounded by patchy wooded areas near the rear and forward abutments, residential properties to the south of the site, and Sycamore Junior High School to the north. As situated within an existing

roadway cut, the elevations at the project site range from about El. 830 near the crest of the cut slopes to roughly El. 816 along the drainage ditches located at the toe.

2.2 Soil and Geologic Setting

A review of the Physiographic Regions of Ohio map (Ohio Division of Geological Survey, 1998) indicates that the project site is located within the Illinoian Till Plain region of the Till Plains section of the Central Lowland province (Exhibit No. 2 in Appendix A). The Illinoian Till Plain region is characterized by moderately low relief (50'), containing many buried valleys and rolling ground moraine of older till generally lacking ice-constructional features such as moraines, kames, and eskers. Modern valleys in the Illinoian Till Plain alternate between broad floodplains and bedrock gorges. Elevations in this region generally range from 600 to 1,100 feet above sea level. Soils in the Illinoian Till Plain generally consist of silt-loam, high-lime, Illinoian-age till with a loess cap over Ordovician and Silurian-age carbonate rocks (limestone) and calcareous shales. According to the Quaternary Geology of Ohio map from the Ohio Department of Natural Resources (ODNR) Division of Geological Survey (Exhibit No. 3 in Appendix A), surficial soils at the site primarily consist of Illinoian aged ground moraine (Ig) consisting of silty loam till, covered with approximately 3 to 10 feet of loess.

2.2.1 Project Soils

The USDA Soil Survey of Hamilton County indicates that the prevalent surficial soil types within the project limits are the Urban land-Udorthents complex (UrUXC and UsUXF) and Urban land-Alfic Udarents complex (UfAXC) units as shown in Exhibit No. 4.

Soils of the Urban land-Udorthents complex (0 to 12 percent slopes) consist of 60 percent urban land, and 40 percent Udorthents and similar soils. Soils of the Urban land-Udorthents complex (0 to 50 percent slopes) consist of 70 percent urban land, and 30 percent Udorthents and similar soils. These high runoff soils are typically found in urban areas, have been modified or transported by human activity, and contain a restrictive feature that impedes water infiltration.

Soils of the Urban land-Alfic Udarents complex (0 to 12 percent slopes) consist of 55 percent urban land, 40 percent Alfic Udarents and similar soils, and 5 percent minor components. The Alfic Udarents parent material consists of loess over pedisegment over till. The Alfic Udarents soil generally consist of silty clay loam and clay loam. These moderately well drained soils are typically located on till plains, with a very low to moderately high-water capacity.

As these soils are urban fills and have been subjected to development and disturbances throughout the years, the current USDA Soil Survey of Hamilton County does not provide steel or concrete corrosion risk nor pH levels within the mapped units. However, review of the soil survey issued in 1982, places the project site within the Rossmoyne-Urban Land complex, which has a high risk of corrosion for concrete and uncoated steel.

2.2.2 Bedrock Geology

As shown on Exhibit No. 5 (Bedrock Geology Map), the geology mapped within the project area is the Ordovician-age bedrock of the Grant Lake Formation, with the Ordovician-age Waynesville Formation and Arnheim Formations Undivided, and Miamitown Shale-Fairview Formation Undivided located within a mile of the project site. Bedrock of the Grant Lake Formation (Oglf), Waynesville Formation and Arnheim Formations Undivided (Owa), and Miamitown Shale-Fairview Formation Undivided (Omf)

generally consist of interbedded limestone and shale. The Bedrock Topography Map (Exhibit No. 6) shows the bedrock elevation just east and south of the project site to be near El. 800.

Based on review of the ODNr Mine Maps as shown in Exhibit No. 7 (Mines of Ohio Map), no mining was mapped within the immediate project area.

3 EXPLORATION

3.1 Previous Explorations

Review of ODOT's Transportation Information Mapping System (TIMS) revealed a past geotechnical study, HAM-71-12.23 performed in 1964, with a test boring performed near each abutment of the existing pedestrian bridge. The north abutment boring, performed at Sta. 264+35, 90 feet left of the centerline, has been redesignated as Boring B-001-0-64. The south abutment boring, performed at Sta. 264+35, 75 feet right of the centerline, has been redesignated as Boring B-002-0-64. The information provided from this study included final boring logs, a geotechnical profile sheet, and laboratory test results. Based on the information provided, the materials consist of Sandy Silt (A-4a), Silty Clay (A-6b), and Clay (A-7-6). Bedrock was encountered at depths of 18 to 22.5 feet below grade (El. 810.7 to 806.1) and was comprised of brownish-gray to gray shale, interbedded with about 30% to 40% limestone in 0.2 to 0.4-foot thick foot interbeds. The approximate locations of the previous explorations are shown on Exhibit No. 8 (Boring Location Plan) in Appendix A. Copies of the historic geotechnical data are in Appendix B.

3.2 Site Reconnaissance

A geotechnical site reconnaissance of the project area was performed by an HDR geotechnical engineer on August 9, 2024. The HAM-126-19.50 pedestrian bridge project site is located in an urban setting surrounded by predominantly residential parcels. The pedestrian bridge spans SR 126, connecting the Kenview Hills neighborhood on the south end and Sycamore Junior High School on the north. The existing terrain is relatively level to gently sloping within the neighborhood and school property, sloping down to the level of SR 126. Patchy wooded areas with thick undergrowth are located near both bridge abutments, but are more prevalent at the south abutment. An overhead truss sign spans eastbound SR 126 just west of the existing bridge, and light poles are located near the first and last bridge piers on either side of the highway.

The existing pedestrian bridge is comprised of a four-span continuous steel bridge with a reinforced concrete deck. Fencing or barriers line both sides of the bridge, as well as the walkway at either end. The top surface of the bridge deck was generally observed to be in fair condition, though spalling concrete and exposed rebar could be observed on the underside of the deck. The girders supporting the deck were also observed to be in fair condition, with areas of rust, and apparent impact damage on the northeast side of the bridge.

3.3 Subsurface Exploration

Four borings were drilled as part of the geotechnical exploration program to assess the subsurface conditions within the HAM-126-19.50 project limits. The locations of the test borings are shown on the Boring Location Plan (Exhibit No. 8) in Appendix A. The test borings were located and marked in the

field during the site reconnaissance. These as-drilled locations are reflected on the boring plan, the boring logs in Appendix C, and Table 3-1.

Table 3-1. Summary of Bridge Structure Borings

Boring Number	Boring Type ¹	Alignment	Station ²	Offset ²	Surface (El., ft) ³	Top of Bedrock (El., ft.)	Bottom of Borehole (El., ft.)
B-001-0-24	E3b	SR 126	262+98	95' RT	825.0	807.5	795.0
B-002-0-24	E1/E3b	SR 126	264+10	62' RT	818.0	806.5	796.2
B-003-0-24	E1/E3b	SR 126	264+25	58' LT	822.0	810.1	797.5
B-004-0-24	E3b	SR 126	262+85	84' LT	823.0	810.5	799.7
1. ODOT Boring Designations: Bridge Structure (E1), Retaining Walls More Than 8 Feet High (E3b) 2. Station and Offsets estimated based on site features, aerial map, and design plans 3. Elevation estimated based on design plans and topographic maps							

The borings were drilled by NEAS from September 24 - 26, 2024, under the supervision of an HDR geotechnical engineer, with a CME 55 track rig (SN 360365). The rig was calibrated on March 8, 2024, and has an energy ratio of 79.9%. All borings were drilled in general accordance with the *Specifications for Geotechnical Explorations* (ODOT revised July 2024) utilizing 3.25-inch internal diameter hollow stem augers to advance the borings to the top of bedrock. The sampling of the soils and weathered bedrock was accomplished in accordance with the *Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils*, ASTM D 1586. The number of blows required to advance the sampling spoon the last 12 inches of a typical 18-inch penetration is recorded as the standard penetration test (SPT) resistance or N_{SPT} -value. The N_{SPT} -value is then corrected to an energy ratio of 60%, termed N_{60} , which is used for design. Undisturbed soil samples were also collected as directed by the geotechnical engineer in accordance with the *Standard Practice for Thin-Walled tube Sampling of Soils for Geotechnical Purposes*, ASTM D 1587.

Sampling of the underlying bedrock was performed in accordance with the *Standard Practice for Rock Core Drilling and Sampling of Rock for Site Investigation*, ASTM D 2113, using an NQ2-size double tube-swivel barrel with a diamond bit. Boring logs and photographs of the recovered rock core samples are provided in Appendix C.

3.4 Laboratory Testing

Representative soil and rock samples were selected by HDR for laboratory testing to confirm the field classification and to assess the various engineering properties of the earth materials. Soil index testing included 30 natural moisture content tests (per ASTM D 2216), 17 Atterberg limit determinations (per ASTM D 4318), and 17 grain size analyses (per ASTM D 422). The results of the soil index tests are presented on the final boring logs located in Appendix C. In addition to the soil index testing, 2 unconfined compression tests (ASTM D 2166) and 2 one-dimensional consolidation (ASTM D 2435) were performed on the relatively undisturbed Shelby tube samples. One (1) point load test (ASTM D5731) and 1 unconfined compression test (ASTM D 7012 – Method C) were also performed on shale and limestone bedrock samples, respectively. The results of these tests are presented on the individual laboratory sheets included in Appendix D.

4 FINDINGS

The soil profile as encountered in the four test borings generally consists of clay extending to shale with interbedded limestone bedrock at a depth of approximately 11.5 to 17.5 feet (El. 806.5 to 810.5) below the existing ground surface. The cohesive overburden was classified as medium stiff to hard Silty Clay (A-6b) and very stiff to hard Clay (A-7-6), with the exception of dense Stone (Weathered Limestone) Fragments (A-1-b) encountered from 9 feet to 11.5 feet (El 809.0 to El 806.5) in Boring B-002-0-24. The underlying shale with interbedded limestone is comprised of approximately 53% to 71% shale and 29% to 47% limestone, depending upon location. The shale was described as very weak, and the limestone as strong to very strong. Recorded Stratum Rock Quality Designations (SRQDs) ranged from 7% to 37%.

Groundwater was not encountered in any of the borings during drilling. Water levels upon completion were not obtained as water was introduced into the boreholes during the rock coring process. Delayed water readings were also not obtained as the borings were sealed immediately upon completion given their location near the travelled way. Groundwater levels at the site are expected to vary depending upon precipitation and other seasonal variations.

5 ANALYSES AND RECOMMENDATIONS

The project involves the replacement of an existing pedestrian bridge over SR 126. The 143-foot single-span, twin steel plate girder bridge with reinforced concrete deck and approach slabs will be supported by pre-bored piles at each end. The pathway leading to the bridge will be supported by MSE Walls.

5.1 Determination of Soil and Rock Parameters

Soil parameters were developed primarily from published correlations with SPT data and plasticity indices, recorded pocket penetrometer readings, the unconfined compressive strength testing, and our engineering experience and judgement. A summary of the recommended soil strength parameters and design profile elevations for the rear and forward abutments are provided in Table 5-1 and Table 5-2. Details of the parameter development are located in Appendix E.

Table 5-1: Recommended Soil Strength Parameters - Forward Abutment

Recommended Design Profile ¹		Material	Unit Wt. ²		Undrained Shear Strength		Drained Shear Strength	
Top Elevation (ft)	Bottom Elevation (ft)		γ_T (pcf)	γ_{eff} (pcf)	S_u (psf)	ϕ' (°)	c' (psf)	ϕ' (°)
Varies	Varies	Select Granular Backfill ⁴	120	57.6	0	34	0	34
822.0	810.0 ³	Layer 2 (Cohesive Soil)	130	67.6	2400	0	250	25

1. Layer breaks are based on Boring B-003-0-24 and B-004-0-24.
 2. Effective unit weights to be used below groundwater (assumed at El. 810.5 in the recommended design soil profile).
 3. Approximate top of bedrock elevation.
 4. Select Granular Backfill, as provided on ODOT BDM Table 307-1 and ODOT SS840 Table 840.04-1.

Table 5-2: Recommended Soil Strength Parameters - Rear Abutment

Recommended Design Profile ¹		Material	Unit Wt. ²		Undrained Shear Strength		Drained Shear Strength	
Top Elevation (ft)	Bottom Elevation (ft)		γ_T (pcf)	γ_{eff} (pcf)	S_u (psf)	ϕ' (°)	c' (psf)	ϕ' (°)
Varies	Varies	Select Granular Backfill ⁴	120	57.6	0	34	0	34
825.0	809.0	Layer 2 (Cohesive Soil)	130	67.6	2400	0	250	25
809.0	806.5 ³	Layer 3 (Cohesive Soil)	130	67.6	4000	0	440	28

1. Layer breaks based on Boring B-001-0-24 and B-002-0-24.
 a. The top 3 feet of soil encountered below the existing ground surface at Boring B-001-0-24 is assumed to consist of Layer 2 material rather than Layer 1 given the boring's location within the existing drainage ditch.
 2. Effective unit weights to be used below groundwater (assumed at El. 807.5 in the recommended design soil profile).
 3. Approximate top of bedrock elevation.
 4. Select Granular Backfill, as provided on ODOT BDM Table 307-1 and ODOT SS840 Table 840.04-1.

The recommended design parameters for design of the bridge foundations in the underlying shale and limestone bedrock are provided in the sections and tables below. The details of the parameter development for both soil and rock are located in Appendix E.

Table 5-3: Recommended Bedrock Design Parameters

Rock Type	Unconfined Compressive Strength Qu (psi)	Slake Durability Index SDI (%)	Rock Quality Designation RQD (%)	Unit Weight (pcf)	Rock Mass Rating, RMR (dim)	Unfactored Unit Side Resistance (psf) ¹	Unfactored Unit Tip Resistance (psf) ¹
Shale	450	--	20	155	13	980	1,130
Limestone	16,150	--	20	165	58	5,850	40,300

1. Calculated based on AASHTO Equation 10.8.3.5.4c-1 (per ODOT GDM) for drilled shafts in rock.

5.2 Pile Foundations

Given the relatively shallow depth to bedrock at the project site, the use of pile foundations will require the placement of the piles into prebored holes extending a minimum 5 feet into bedrock, as discussed in the ODOT BDM 305.3.5.7. In addition to this minimum 5 feet, the ODOT BDM and GDM requires a minimum socket length of 10 feet for bedrock with a strength less than 1500 psi. While the compressive strength of the limestone is greater than 1500 psi, the strength of the interbedded shale is less than 1500 psi. Furthermore, the augers were able to penetrate through the upper 1.0 feet to 2.5 feet of bedrock and the interbedded shale and limestone sampled with SPT methods at Borings B-001-0-24, B-003-0-24 and B-004-0-24. Therefore, it is recommended that the prebored holes extend a minimum of 10 feet below the top of the bedrock. For piles placed in such prebored holes and not subjected to driving stresses or potential driving damages, a structural resistance factor of 0.95 may be applied in determining the factored axial resistance for the respective pile section per the ODOT BDM and GDM. The factored axial resistances for selected HP Sections are listed in Table 5-4 below.

Table 5-4: Factored Structural Resistance for Selected Piles

Pile Section	Cross-Sectional Area of Steel Section (in ²)	Factored Axial Resistance ¹ (kips)
HP 10x42	12.4	585
HP 12x53	15.5	735
HP 14x73	21.4	1,015

1. Based on 50 ksi steel and a structural resistance factor, $\phi_c = 0.95$, for piles placed in prebored holes in accordance with ODOT BDM 305.3.5.7 and ODOT GDM 1305.1.

As vertical piles are expected, Tables 5-5 and 5-6 provides a summary of the recommended design parameters for lateral analyses performed using the LPILE software program by Ensoft. Any piles spaced closer than five (5) pile widths must also consider group effects.

Table 5-5. Recommended Lateral Design Parameters - Forward Abutment¹

Recommended Design Profile ²		Material	Unit Wt.		E50 ³	K (pci) ³		Rock Parameters		
Top Elevation (ft)	Bottom Elevation (ft)		γ_T (pcf)	γ_{Eff} (pcf)		Above Ground Water	Below Ground Water	Qu (psi)	Modulus of Rock Mass ⁴ (psi)	RQD
Varies	Varies	Select Granular Backfill	120	57.6	-	225	125	-	-	-
822.0	810.1	Layer 2 (Cohesive Soil)	140	77.6	0.005	-	-	-	-	-
810.1	807.5	Shale (Weak Rock) ⁵	-	155	-	-	-	100	34,200	0
807.5	797.5	Shale (Weak Rock)	-	155	-	-	-	450	34,200	20
- Any piles spaced closer than five (5) pile widths must also consider group effects. - Layer breaks based on Boring B-003-0-24. ϵ_{50} and k values per LPile Technical Manual. - Modulus of Rock Mass for Very Weak Shale bedrock adopted for Weathered Shale and Limestone bedrock with SPT. - Weathered Shale and Limestone bedrock with SPT.										

Table 5-6: Recommended Lateral Design Parameters - Rear Abutment¹

Recommended Design Profile ²		Material	Unit Wt.		E50 ³	K (pci) ³		Rock Parameters		
Top Elevation (ft)	Bottom Elevation (ft)		γ_T (pcf)	γ_{Eff} (pcf)		Above Ground Water	Above Ground Water	Qu (psi)	Modulus of Rock Mass (psi)	RQD
Varies	Varies	Select Granular Backfill	120	57.6	-	225	125	-	-	-
818.0	815.5	Layer 1 (Cohesive Soil)	120	57.6	0.007	-	-	-	-	-
815.5	809.0	Layer 2 (Cohesive Soil)	140	77.6	0.005	-	-	-	-	-
809.0	806.5	Layer 4 (Granular Soil)	130	67.6	-	225	125	-	-	-
806.5	796.2	Shale (Weak Rock)	-	155	-	-	-	450	34,200	20
- Any piles spaced closer than five (5) pile widths must also consider group effects. - Layer breaks based on Boring B-002-0-24. ϵ_{50} and k values per LPile Technical Manual.										

5.3 Mechanically Stabilized Earth Walls

Analyses were performed to determine the external stability of the proposed Mechanically Stabilized Earth (MSE) walls. These analyses included global slope stability, bearing resistance, sliding, and settlement. The external wall stability evaluations were performed in accordance with LRFD criteria using the adopted soil properties for the foundation soils presented earlier in Section 5.2. These parameters were developed based on shear strength tests, published correlations with SPT data and plasticity indices, recorded pocket penetrometer readings, and our engineering experience and judgment. Documentation of the development of the short- and long- term parameters is located in Appendix E

The external stability analyses of the MSE walls were performed using the computer software MSEW 3.0 (ADAMA Engineering, Inc, 2019) based on determined soil parameters values for the existing subsurface materials and the MSE wall material (select granular backfill) parameters as provided in the ODOT GDM. As the MSEW software models the soils directly supporting the MSE wall (foundation soils) as a single layer, the parameters for the soils located at the bottom of the wall/leveling pad were used for each respective analysis model.

MSEW software provides a Capacity Demand Ratio (CDR), or the ratio of factored resistances over factored loads, where a minimum CDR of equal to or greater than 1.0 indicates adequate support of the proposed loads. The software was used to determine the CDR for bearing, overturning, and sliding.

The spiraling layout of the MSE walls as shown in the design profile in Appendix E confines the walls to a relatively compact overall footprint, with various segments of the same wall essentially adjacent to one another. This spiraling design creates a situation in which a back-to-back MSE wall is constructed on top of a more standard MSE wall. Therefore, where such a case was present, the wall was analyzed in two steps: 1.) The upper portion of the design section was analyzed as a back-to-back configuration assuming the base to consist of select granular backfill, and 2.) the lower portion of the wall was analyzed assuming a surcharge loading equal to the height of the overlying back-to-back wall multiplied by the unit weight of the select granular backfill and assuming the base of the lower portion of the wall was underlain by the respective encountered existing soils. The tables below summarize the results of the MSE wall analyses.

It should be noted that active-thrust conditions were evaluated for the given back-to-back walls. Although some analyses could be performed assuming partial-active thrust given the wall-to-wall base width, the full-active thrust cases resulted in strap lengths at or near the minimally required 0.7H. As such, wall calculations assuming partial-active thrust conditions were not performed.

Table 5-7: MSEW Wall Reinforcement Analysis Summary –Wall 001

Wall	Design Section	Design Height (ft)	Strap Length		Minimum Required Embedment (ft) ⁵
	Project Alignment Station Location		ft	Per Height ⁴	
001	Section 1 Sta 2+93 ¹	15 ¹	11	0.73	3 or H/10
001	Section 2 Sta 2+93 /Sta 3+18 (Switch Back) ¹	20 ¹	14	0.70	3 or H/10
001	Section 3 Sta 4+07 (Upper Ramp – Back-to-Back) ³	12.5 ³	9	0.72	3 or H/10
001	Section 3 Sta 4+07 (Rear Abutment) ²	17 ²	13	0.76	3 or H/10
001	Section 3 Sta 2+04 (Upper Wall) ³	11 ³	8	0.73	3 or H/10
001	Section 4 Sta 4+07 (End of Wall) ¹	28 ¹	20	0.71	3 or H/10
1. Height of wall measured from the top of the leveling pad to the top of coping 2. Height of wall does not include overlying back-to-back wall section 3. Height of wall includes only the overlying back-to-back wall 4. Minimum strap length of 8 ft or 0.7H of wall height per ODOT 5. Minimum Embedment = Use the greater of the values provided					

Table 5-8: Summary of MSE Wall External Stability Analysis Results - Wall 001

Design Section ¹	Design Wall Height (ft)	Unfactored Bearing Load (psf) ²	Factored Bearing Load (psf) ²	Factored Bearing Resistance (psf) ¹	Capacity Demand Ratio (CDR)		
					Bearing	Sliding	Overturning
Section 1 Sta 2+93	15	2,759	4,034	8,021	2.0	1.5	2.2
Section 2 Sta 2+93 /Sta 3+18	20	3,435	4,949	8,021	1.6	1.8	2.5
Section 3 Sta 4+07 (Upper Ramp Back-to-Back)	12.5	2416	3569	4769	1.3	1.4	2.0
Section 3 Sta 4+07	17	5,599	8,326	13,368	1.6	1.3	1.7
Section 3 Sta 2+04	11	2,171	3,224	4,230	1.3	1.4	1.9
Section 4 Sta 4+07	28	4,571	6,509	13,368	2.1	1.9	2.9
1. See Appendix E 2. Unfactored and Factored Bearing Loads and Factored Bearing Resistance as Calculated by MSEW							

Table 5-9: MSEW Wall Reinforcement Analysis Summary - Wall 002

Wall	Design Section	Design Height (ft)	Strap Length		Required Embedment (ft) ⁵
	Project Alignment Station Location		ft	Per Height ⁴	
002	Section 1 Sta 7+48 ¹	19 ¹	14	0.73	3 or H/10
002	Section 2 Sta 7+16 (Switch Back) ¹	21 ¹	15	0.71	3 or H/10
002	Section 3 Sta 6+17 (Lower Wall) ^{2,6}	13.5 ²	13	0.96	3 or H/10
002	Section 3 Sta 6+17 (Upper Wall) ^{3,6}	15 ³	11	0.73	3 or H/10
002	Section 4 Sta 5+82 (Forward Abutment) ²	18 ²	15	0.83	3 or H/10
002	Section 4 Sta 5+82/Sta 8+83 (Upper Wall) ³	18.5 ³	13	0.70	3 or H/10
002	Section 5 Sta 5+82/Sta 8+83 (End of Wall) ¹	30.5 ¹	21.5	0.70	3 or H/10
1. Height of wall measured from the top of the leveling pad to the top of coping 2. Height of wall does not include overlying back-to-back wall section 3. Height of wall includes only the overlying back-to-back wall 4. Minimum strap length of 8 ft or 0.7H of wall height per ODOT 5. Minimum Embedment = Use the greater of the values provided 6. Intermediate Section Analysis performed given the overlying back-to-back wall height being greater than the underlying wall section.					

Table 5-10: Summary of MSE Wall External Stability Analysis Results –Wall 002

Design Section ¹	Design Wall Height (ft)	Unfactored Bearing Load (psf) ¹	Factored Bearing Load (psf) ²	Factored Bearing Resistance (psf) ²	Capacity Demand Ratio (CDR)		
					Bearing	Sliding	Overturning
Section 1 Sta 7+48	19	3351	4852	8021	1.7	1.6	2.4
Section 2 Sta 7+16 (Switch Back)	21	3542	5085	8021	1.6	1.8	2.7
Section 3 Sta 6+17 (Lower Wall)	13.5	4917	7259	8021	1.1	1.5	2.4
Section 3 Sta 6+17 (Upper Wall)	15	2759	4034	6006	1.5	1.5	2.2
Section 4 Sta 5+82 (Forward Abutment)	18	5612	7757 ³	8021	1.0 ³	1.4	2.0
Section 4 Sta 5+82/Sta 8+83 (Upper Wall)	18.5	3206	4629	7409	1.6	1.8	2.5
Section 5 Sta 5+82/Sta 8+83 (End of Wall)	30.5	5040	7185	8021	1.1	1.8	2.7
1. See Appendix E 2. Unfactored and Factored Bearing Loads and Factored Bearing Resistance as Calculated by MSEW 3. 1-foot undercut and replacement required to meet bearing resistance requirements.							

Our analyses indicate that the MSE walls are externally stable with minimum recommended soil reinforcement lengths (base width) of typically 0.7H to 0.8H for Wall 001 and Wall 002 as shown in Tables 5-7 and 5-9. H is defined as the elevation difference between the top of the coping and the top of the leveling pad at non-abutment locations, and the elevation difference between the profile grade at the face of the wall and the top of the leveling pad at abutment walls per Section 1504 of the ODOT GDM. Given the spiraling layout of the ramps and their compact footprint, the calculated strap lengths were modified to allow for more uniform excavation and ease of construction. A summary of the recommended MSE wall reinforcement schedule is provided in Table 5-11 and Table 5-12 below.

Table 5-11: MSE Wall Reinforcement Schedule – Wall 001

Wall Station		Max Design Wall Height (ft)	Strap Length (ft)
Begin	End		
0+25	0+91.5	15	11
0+91.5	1+40	20	14
1+40	2+24.4	13.5 ¹	13 ³
2+24.4	2+31.19	17	13
2+31.19	2+48.19	28 ⁴	20 ⁵
2+48.19	2+57	17	13
2+57	2+71.67	28	20
2+71.67	2+86	12.5 ²	9 ⁶
2+71.67	2+86	28	20 ⁵
2+83	3+71.26	12.5 ²	9
1. The maximum wall height as presented does not include the overlying back-to-back wall height 2. The maximum height as presented only includes the overlying back-to-back portion of the wall height 3. The strap length is to apply to the entire wall face, including the overlying back-to-back wall portion 4. The wall design is based on a height of 28 feet (the top of leveling pad to the profile grade elevation at the wall face) per SS 840 5. The strap length is to be applied at elevations <u>below</u> the bottom of the proposed abutment pile cap 6. The strap length is to be applied at elevations <u>above</u> the bottom of the proposed abutment pile cap			

Table 5-12: MSE Wall Reinforcement Schedule – Wall 002

Wall Station		Max Design Wall Height (ft)	Strap Length (ft)
Begin	End		
0+27	1+85.91	19	14
1+85.91	2+34	21	15
2+34	3+33	13.5 ¹	13 ³
3+33	3+65.93	18 ¹	15 ³
3+65.93	3+72.46	18	15
3+72.49	3+89.46	30.5 ⁴	21.5 ⁵
3+89.46	3+98.5	18	15
3+98.5	4+14.69	30.5	21.5
4+14.69	4+28	18.5 ²	13 ⁶
4+14.69	4+28	30.5	21.5 ⁵
4+28	5+64.94	18.5 ²	13
1. The maximum wall height as presented does not include the overlying back-to-back wall height 2. The maximum height as presented only includes the overlying back-to-back portion of the wall height 3. The strap length is to apply to the entire wall face, including the overlying back-to-back wall portion 4. The wall design is based on a height of 30.5 feet (the top of leveling pad to the profile grade elevation at the wall face) per SS 840 5. The strap length is to be applied at elevations <u>below</u> the bottom of the proposed abutment pile cap 6. The strap length is to be applied at elevations <u>above</u> the bottom of the proposed abutment pile cap			

5.3.1 Global Slope Stability

The proposed MSE wall retaining system will consist of a reinforced Select Granular Backfill (SGB) to be placed in the reinforced soil zone with retained soil behind it. As shown in the design profile in Appendix E, wall heights of up to approximately 28 feet are anticipated for Wall 001 and 30.5 feet for Wall 002. As such, slope stability analyses were performed at selected sections near the abutment (Sta. 2+04/4+07) and at the switch back (Sta. 2+93/3+18) for Wall 001. Similarly, slope stability analyses were performed for Wall 002 near the abutment (Sta. 5+82/8+83) and near the switch back (Sta. 7+16/7+48). The Wall 001 section utilized the soil profile as encountered at Borings B-001-0-24 and B-002-0-24, where Wall 002 utilized Boring s B-003-0-24 and B-004-0-24. A visual representation of the cross sections selected for the slope stability analyses are provided in Appendix E.

The analyses were performed utilizing the software package Slope/W, a slope stability modeling program within the GEOSTUDIO2022 (Bentley Systems, Inc.) software suite, to analyze circular failure surfaces using the Morgenstern-Price Method where the geometries at these locations were determined using the preliminary MSE wall details and cross sections as presented in the design profile in Appendix E. The slope stability analyses were conducted for the embankments using a targeted minimum factor of safety of 1.5 for both short and long term loading conditions as established by ODOT. A summary of the slope stability analyses is provided in **Error! Reference source not found.**¹³ below, with computer output plots of the analyses presented in Appendix E.

Table 5-13: Summary of Slope Stability Analyses - Factor of Safety

MSE Wall	Station	Proposed Conditions	
		Undrained (Short Term)	Drained (Long Term)
Wall 001	Sta. 2+04/4+07	3.2	1.7
	Sta. 2+93/3+18	5.6	2.4
Wall 002	Sta. 5+82/8+83	8.3	3.4
	Sta. 7+16/7+48	8.7	3.5

5.3.2 Settlement

Analyses were performed at multiple sections along both Wall 001 and Wall 002 to estimate the magnitude and duration of the expected settlement of the foundation soils under the weight of the new MSE wall fill. The consolidation properties of the foundation soils were established based on the results of the one-dimensional consolidation tests performed on relatively undisturbed soil samples collected at the site, as well as our engineering experience and judgment. The existing and proposed stresses at these sections were determined using SIGMA/W, a finite element modeling software within the GEOSTUDIO²⁰¹⁸ suite used to perform stress and deformation analyses of earth structures. As shown in Table 5-14, the maximum amount of settlement as a result of primary consolidation for both Wall 001 and Wall 002 is estimated to be approximately 0.8 inches. The wall settlement analyses along with determinations of existing and proposed stresses are provided in Appendix E.

In addition to one-dimensional consolidation testing, time rate of settlement calculations were performed on the relatively undisturbed samples. One-way drainage was assumed for the settlement calculations as the overlying soils are generally cohesive with the cohesionless stone fragments as encountered in Boring B-002-0-24 not uniformly distributed throughout the site. Based on the test

results and drainage assumptions, the time needed to reach 90 percent settlement is generally about 5 to 10 months. However, the time needed to reach 90% consolidation is inconsequential given the estimated amount of consolidation settlement (< 1 inch).

Table 5-14: Summary of Estimated Settlement

Station	Offset	Compressible Layer Thickness (ft) ¹	Consolidation Settlement (in)	Time Rate of Settlement	
				50% (Months)	90% (Months)
Sta. 2+04	CL	20	0.6	2	19
	8.5 RT	16.5	0.8	2	16
	25 RT	4.5	0.3	1	5
Sta. 2+93	8.5 LT	11.5	0.3	0.5	9
	7.5 RT	11	0.3	0.5	5
	25 RT	7	0.3	1	5
Sta. 5+82	2 LT	7	0.2	0.2	3
	8.5 RT	12.5	0.8	1	10
	25 RT	12.5	0.1	1	10
Sta. 7+16	8 LT	6	0.4	0.5	2
	9.5 RT	10.5	0.8	1	7
	25 RT	9	0.4	0.5	6

1. Measured from top of MSE wall leveling pad to the top of bedrock.

The differential settlement anticipated to occur along the MSE wall was also determined. As shown in Table 5-15, the predicted differential settlement is less than 0.5 percent, allowing for the use of the standard 10-foot wide facing panels.

Table 5-15: Summary of Differential Settlement

Station	Offset	Consolidation Settlement (in)	Station	Offset	Consolidation Settlement (in)	Wall Section Length (ft)	Differential Settlement	
							(in)	Angular Distortion ¹
Sta. 2+04	CL	0.6	Sta. 2+93	8.5 LT	0.3	89	0.3	0.028%
Sta. 2+04	8.5 RT	0.8	Sta. 2+93	7.5 RT	0.3	89	0.5	0.047%
Sta. 2+04	25 RT	0.2	Sta. 2+93	25 RT	0.3	89	0.1	0.009%
Sta. 5+82	2 LT	0.2	Sta. 7+16	8 LT	0.4	134	0.2	0.012%
Sta. 5+82	8.5 RT	0.8	Sta. 7+16	9.5 RT	0.8	134	0.0	0.000%
Sta. 5+82	25 RT	0.1	Sta. 7+16	25 RT	0.4	134	0.4	0.025%
1. (Differential Settlement / Wall Section Length) x 100								

5.4 Recommendations

5.4.1 Site Preparation

- Site preparation activities at the project site should be performed in accordance with Item 201 and Item 202 of the current edition of the CMS. These activities are anticipated to include clearing and grubbing, as well as the removal of the existing bridge structure and its associated appurtenances.

5.4.2 Pile Foundations

- It is recommended that the bridge abutments be supported on steel H-piles prebored 10 ft into the underlying bedrock in accordance with the ODOT BDM and the ODOT GDM.
- Design the piles in compression using a maximum resistance factor (ϕ_c) of 0.95 for piles placed in prebored holes in accordance with ODOT BDM 305.3.5.7 and ODOT GDM 1305.1.
- Design of the piles should not exceed the maximum factored axial pile resistances provided in Table 5-4.
- Pile splices must be capable of developing the full strength of the pile.
- A minimum center-to-center pile spacing of three (3) pile widths is recommended.
- As vertical piles are expected, lateral analyses should be performed utilizing the recommended design parameters as provided in Table 5-5 and Table 5-6. Any piles spaced closer than five (5) pile widths must consider group effects

5.4.3 MSE Walls 001 and 002

- The soil reinforcement length shall not be less than the lengths provided for each station range as shown in Table 5-7 for Wall 001 and Table 5-9 for Wall 002.
- The select fill used within the reinforcement zone should conform to the ODOT select granular backfill (SGB) as presented in Section 840.02E of ODOT Supplemental Specification 840. The

granular material should be capable of providing a minimum friction angle (ϕ) of 34 degrees and should not possess a moist unit weight in excess of 120 pounds per cubic foot.

- Standard 10-foot wide facing panels should be used. Per the ODOT BDM, the minimum thickness of the facing panel should be 5.5 inches.
- The distance between the top of the leveling pad and the ground surface at any point on the ground surface within 4 feet of the face of the wall should be 3 feet.
- A 1-foot undercut and replacement below the leveling pad elevation and replacement with Granular Material Type C is needed to meet the required bearing resistance beginning at the Forward Abutment (Wall 002) from approximately Project Centerline Sta. 5+60 to Sta. 6+18. Additional undercut excavation beyond 12 inches is not anticipated. An undercut is not required at Wall 001.
- Final design of the MSE walls should conform to Section 11.10 of the AASHTO LRFD Bridge Design Specifications, Seventh Edition, the latest version of the ODOT Bridge Design Manual and ODOT Supplemental Specification 840.

6 LIMITATIONS

This report documents the findings and conclusions of HDR Engineering, Inc., for the geotechnical aspects related to the planning and design of the HAM-126-19.50 project in Hamilton County, Ohio. The report has been prepared for the use of the Ohio Department of Transportation for specific application to this project, in accordance with generally accepted engineering practice. No warranty, expressed or implied, is made. Any analyses or recommendations submitted are based on the field explorations performed at the locations indicated, on specific laboratory tests on individual samples taken during the exploration program, and information obtained from outside sources. The report and analyses do not reflect variations that could occur between borings or at other points in time. Variations in conditions, if any, may become evident during the construction period, at which time a re-evaluation of the recommendations may become necessary. In the event of such changes, the recommendations and changes should be reviewed by HDR's geotechnical staff.

7 REFERENCES

State of Ohio Department of Transportation (Updated July 2024); “*Specifications for Geotechnical Explorations.*”

State of Ohio Department of Transportation (Updated July 2024); “*Geotechnical Design Manual.*”

State of Ohio Department of Transportation (Updated July 2024); “*Bridge Design Manual.*”

State of Ohio Department of Transportation (Updated July 2024); “*Location and Design Manual, Volume 2 – Drainage Design.*”

United States Department of Agriculture: Natural Resources Conservation Service (2024); “Web Soil Survey”. <http://websoilsurvey.nrcs.usda.gov/app/>

Ohio Department of Natural Resources, Division of Geologic Survey (2024); “Ohio Geology Interactive Map”. <https://ohiodnr.gov/business-and-industry/services-to-business-industry/gismapping-services/ohio-geology-interactive-map>

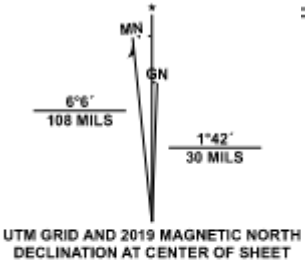
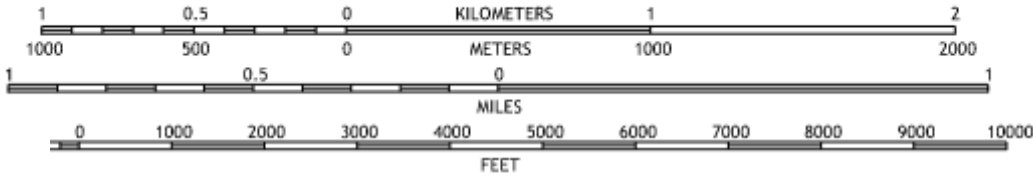
Ohio Department of Natural Resources, Division of Geologic Survey and Division of Mineral Resources (2024); “Mines of Ohio”. <https://gis.ohiodnr.gov/MapView/?config=OhioMines#>

Ohio Department of Natural Resources, Division of Geologic Survey, (1998) “Physiographic Regions of Ohio”.

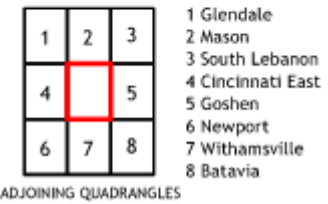
Appendix A. Exhibits



SCALE 1:24 000



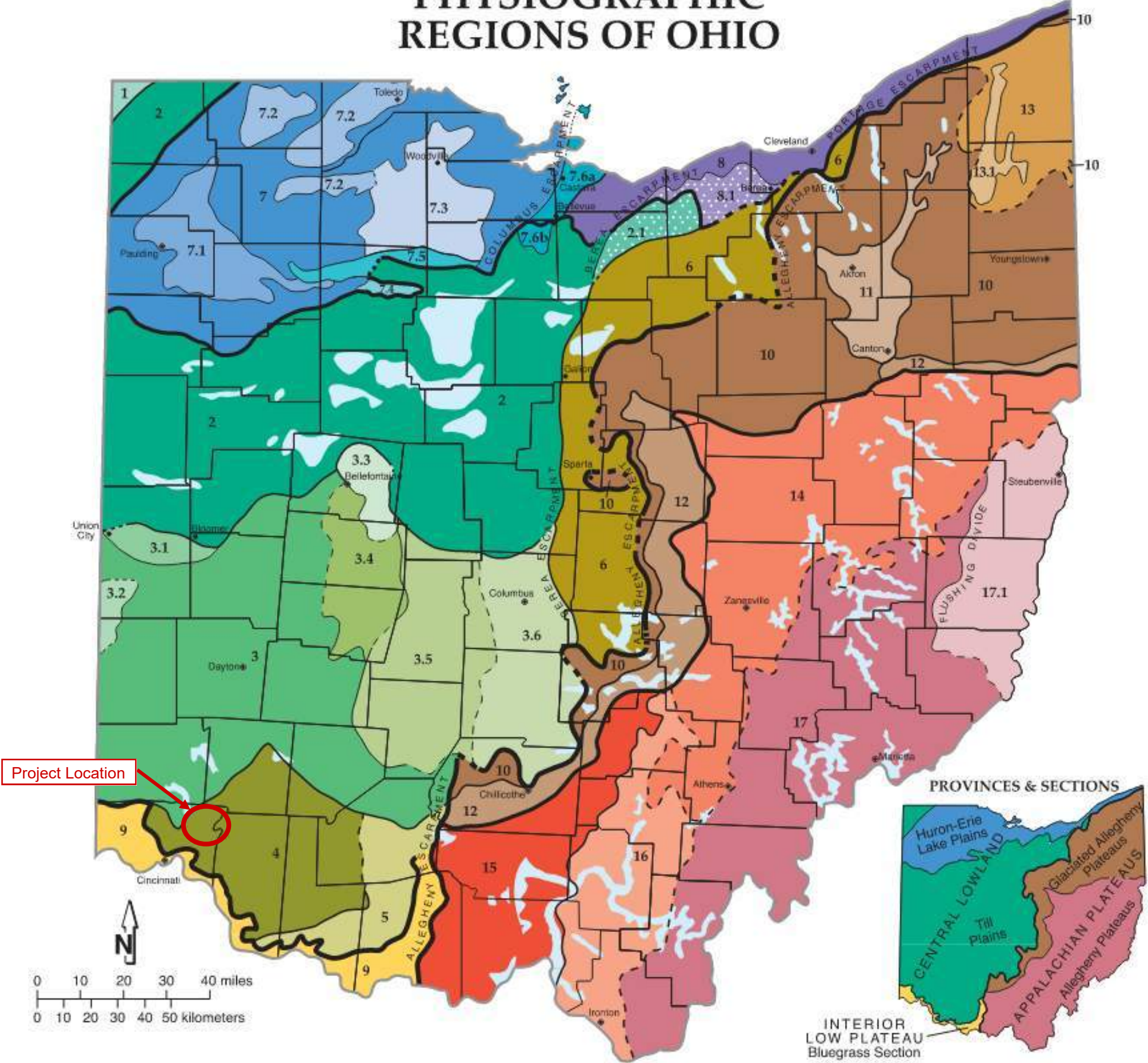
CONTOUR INTERVAL 10 FEET
NORTH AMERICAN VERTICAL DATUM OF 1988
This map was produced to conform with the
National Geospatial Program US Topo Product Standard, 2011.
A metadata file associated with this product is draft version 0.6.18



MADEIRA, OH
2019

Produced by the United States Geological Survey
North American Datum of 1983 (NAD83)
World Geodetic System of 1984 (WGS84). Projection and
1 000-meter grid: Universal Transverse Mercator, Zone 16S
This map is not a legal document. Boundaries may be
generalized for this map scale. Private lands within government
reservations may not be shown. Obtain permission before
entering private lands.
Imagery.....NAIP, September 2015 - October 2015
Roads.....U.S. Census Bureau, 2016
Names.....GNIS, 1979 - 2019
Hydrography.....National Hydrography Dataset, 1899 - 2019
Contours.....National Elevation Dataset, 2010
Boundaries.....Multiple sources; see metadata file 2017 - 2018
Public Land Survey System.....BLM, 2017
Wetlands.....FW5 National Wetlands Inventory 2004 - 2007

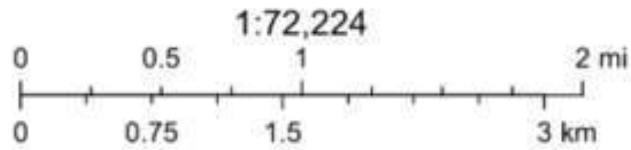
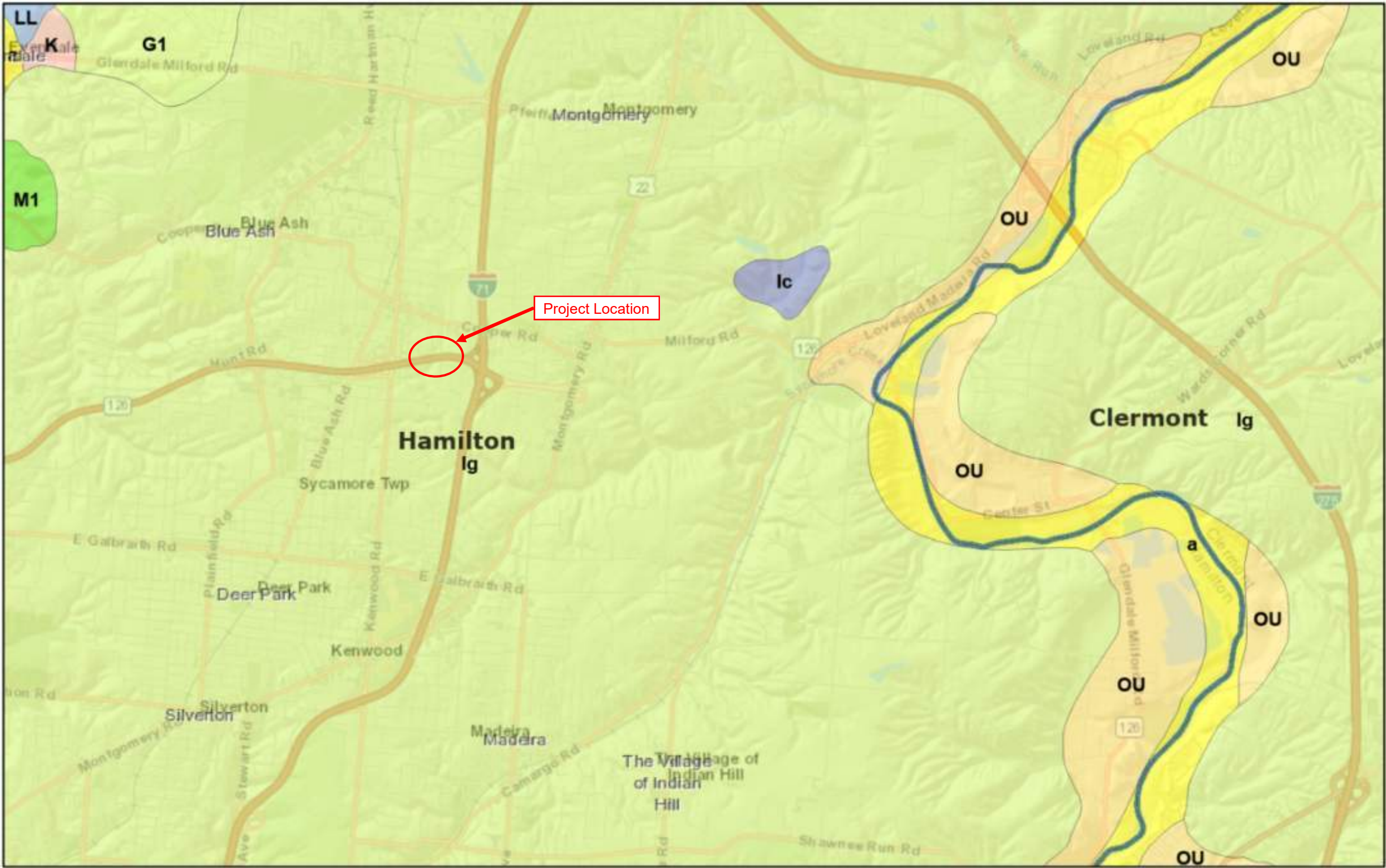
PHYSIOGRAPHIC
REGIONS OF OHIO



- Till Plains**
- 1. Steuben Till Plain
 - 2. Central Ohio Clayey Till Plain
 - 2.1. Berea Headlands of the Till Plain
 - 3. Southern Ohio Loamy Till Plain
 - 3.1. Union City-Bloomer Transitional Terrain
 - 3.2. Whitewater Interlobate Plain
 - 3.3. Bellefontaine Upland
 - 3.4. Mad River Interlobate Plain
 - 3.5. Darby Plain
 - 3.6. Columbus Lowland
 - 4. Illinoian Till Plain
 - 5. Dissected Illinoian Till Plain
 - 6. Galion Glaciated Low Plateau
- Huron-Erie Lake Plains**
- 7. Maumee Lake Plains
 - 7.1. Paulding Clay Basin
 - 7.2. Maumee Sand Plains
 - 7.3. Woodville Lake-Plain Reefs
 - 7.4. Findlay Embayment
 - 7.5. Fostoria Lake-Plain Shoals
 - 7.6a and 7.6b. Bellevue-Castalia Karst Plain
 - 8. Erie Lake Plain
 - 8.1. Berea Headlands of the Erie Lake Plain
- Bluegrass Section**
- 9. Outer Bluegrass Region
- Glaciated Allegheny Plateaus**
- 10. Killbuck-Glaciated Pittsburgh Plateau
 - 11. Akron-Canton Interlobate Plateau
 - 12. Illinoian Glaciated Allegheny Plateau
 - 13. Grand River Low Plateau
 - 13.1 Grand River Finger-Lake Plain
- Allegheny Plateaus**
- 14. Muskingum-Pittsburgh Plateau
 - 15. Shawnee-Mississippian Plateau
 - 16. Ironton Plateau
 - 17. Marietta Plateau
 - 17.1. Little Switzerland Plateau
- PROVINCES & SECTIONS**
- Huron-Erie Lake Plains
 - CENTRAL LOWLAND
 - Till Plains
 - APPALACHIAN PLATEAUS
 - Glaciated Allegheny Plateaus
 - Allegheny Plateaus
- Transitional boundary
Lake basin/deposits outside Huron-Erie Lake Plains

Reference:
Ohio Division of Geological Survey, 1998
Physiographic Regions of Ohio,
Ohio Dept. of Natural Resources, Division of Geological Survey

Exhibit No. 2 : Physiographic Regions of Ohio	Calculated: MM	Checked: DCM
	Project: HAM-126-19.50	PID: 114652



Geologic Mapping Unit Descriptions
Quaternary Geology Unit Name

Ig	Ground moraine, flat, relatively continuous
Ic	Lacustrine deposits, clays and silts, massive or laminated; loess or colluvial cover 0.25 to 0.5 meter thick

Source: ODNR Division of Geological Survey
<https://gis.ohiodnr.gov/website/dgs/geologyviewer/#>

Calculated: MM	Exhibit No. 3 : Surficial Geology	Project: HAM-126-19.50 PID: 114652
Checked: DCM		



Area of Interest (AOI)

Area of Interest (AOI)

Soils

- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Water Features

Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Hamilton County, Ohio
Survey Area Data: Version 23, Sep 6, 2023

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Oct 28, 2019—Dec 5, 2019

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
UfAXC	Urban land-Alfic Udarents complex, fragipan substratum over till, 0 to 12 percent slopes	0.4	16.0%
UrUXC	Urban land-Udorthents complex, 0 to 12 percent slopes	0.6	25.4%
UsUXF	Urban land-Udorthents complex, smoothed, 0 to 50 percent slopes	1.4	58.6%
Totals for Area of Interest		2.4	100.0%

Source: USDA Natural Resources Conservation Services
<https://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx>

Calculated: MM

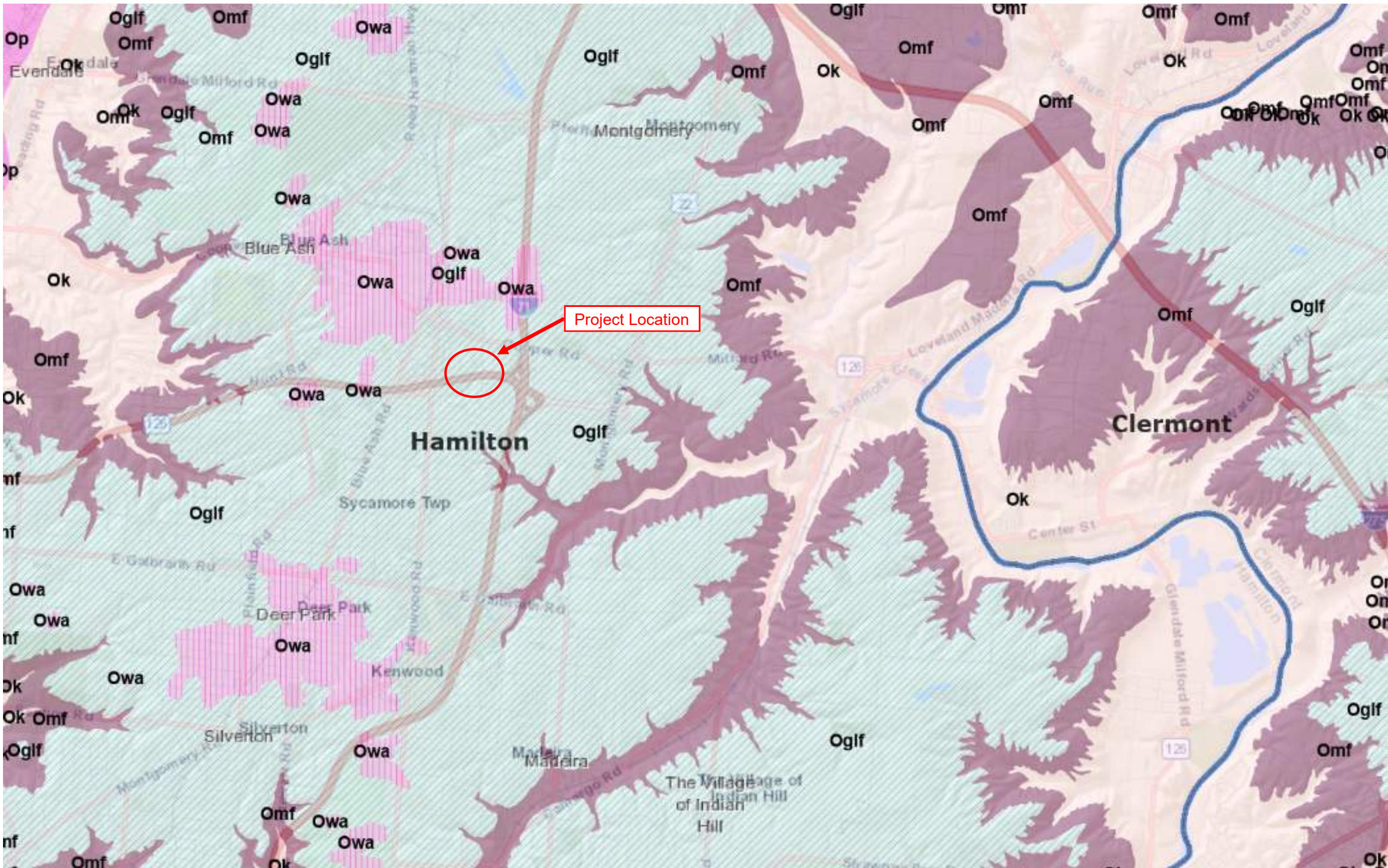
Checked: DCM

Exhibit No. 4 : Soil Survey Map

Soil Types

Project: HAM-126-19.50

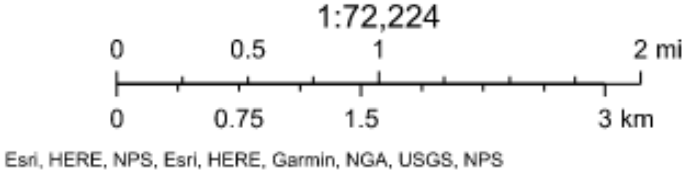
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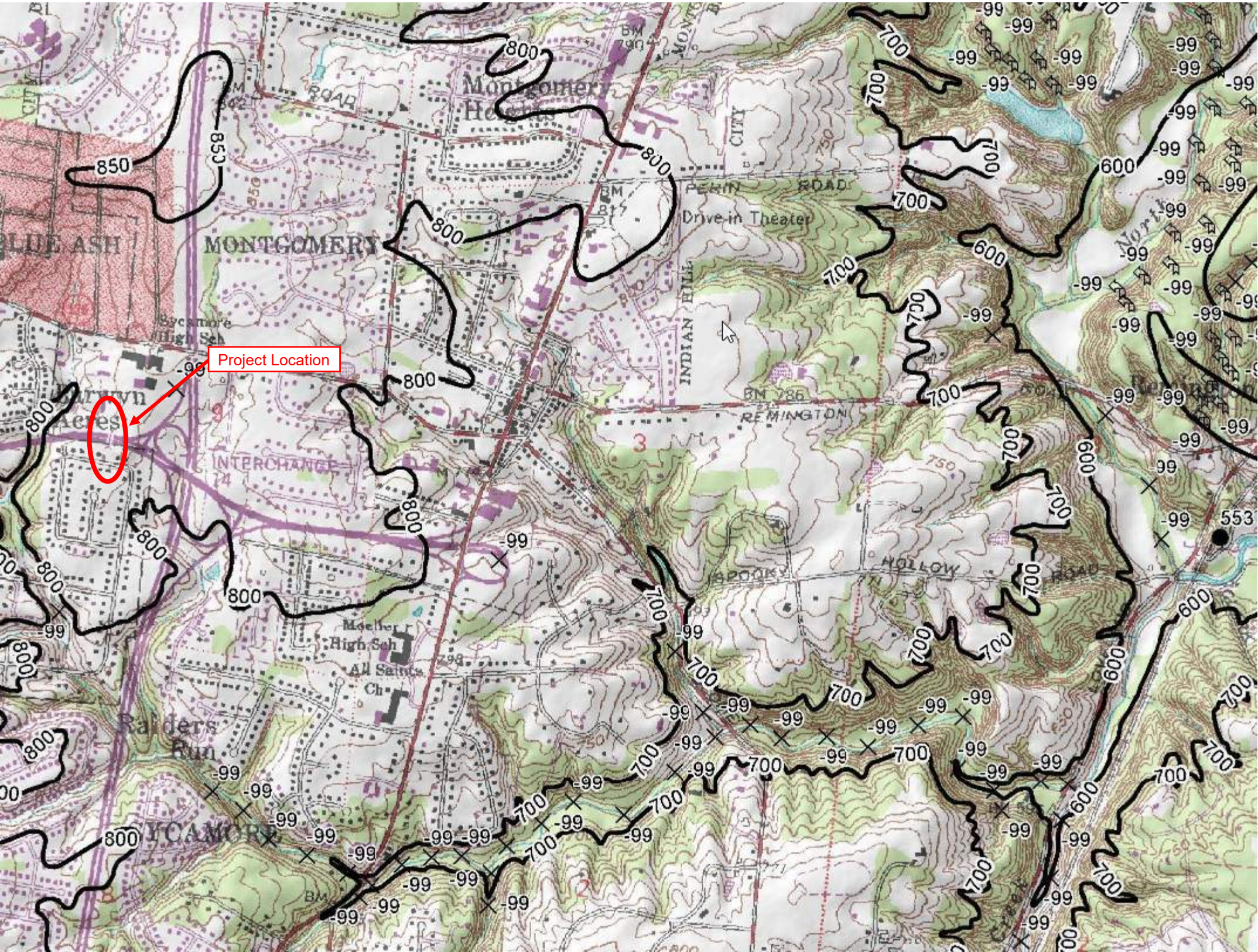
Geologic Unit

- Owa - Waynesville Formation And Arnheim Formations Undivided
- Oglf - Grant Lake Formation
- Omf - Miami Shale-Fairview Formation Undivided
- Ok - Kope Formation
- Op - Point Pleasant Formation

Source: ODNR Division of Geological Survey
<https://gis.ohiodnr.gov/website/dgs/geologyviewer/#>



Calculated: MM	Exhibit No. 5 : Bedrock Geology Map	Project: HAM-126-19.50 PID: 114652
Checked: DCM		



LOCATION MAP

Project: HAM-126-19.50 PID: 114652	Exhibit No. 6 : Bedrock Topography Map	Calculated: MM Checked: DCM
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Mines of Ohio



August 13, 2024

Quadrangle 24K (7.5 min)



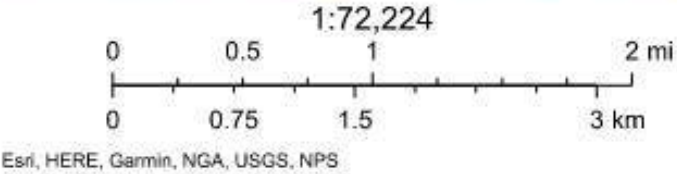
Historic - From Topo Maps



Past



Surface Affected Area



Source: ODNR Division of Geological Survey, Mines of Ohio Interactive Map
<https://gis.ohiodnr.gov/MapView/?config=OhioMines>

Calculated: MM	Exhibit No. 7 : Mines of Ohio Map	Project: HAM-126-19.50 PID: 114652
Checked: DCM		

Appendix B. Historic Information

Latitude: 39.226496,
Longitude: -84.369912

Water Elev. _____

Dia.

Surface Elev. 828.7'

[illegible]

Latitude: 39.226008
Longitude: -84.370019

Date Started 2-28-64

Sampler Type SS Dia. 1 3/8"

Water Elev. _____

Date Completed 3-3-64

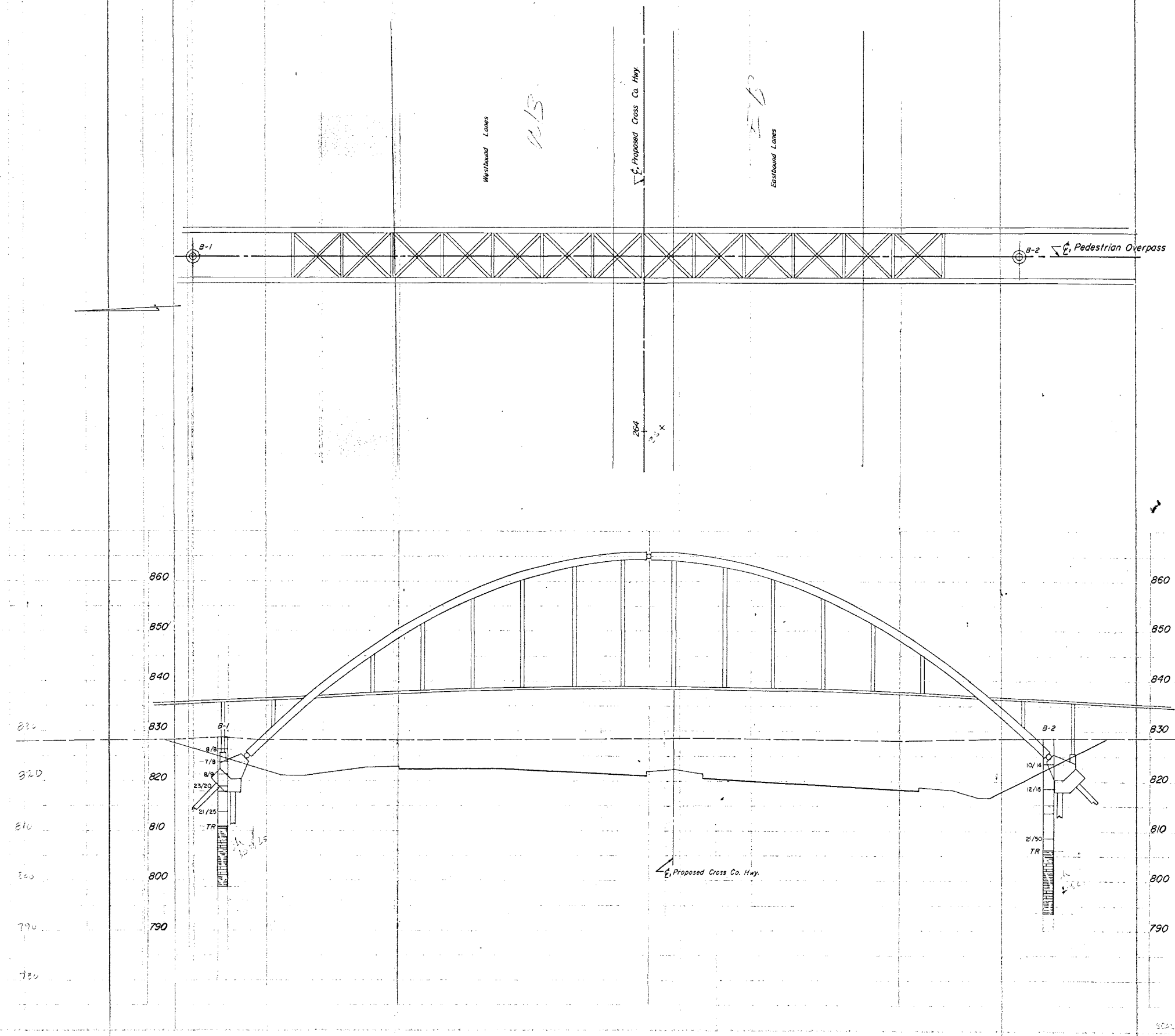
Casing: Length 15' Dia. 3 1/2"

Boring No. B-2

Station & Offset 264+35.75' Rt (PED. OVERPASS)

Surface Elev. 828.6'

Elev.	Depth	Std. Pen. (N)	Rec. ft.	Loss ft.	Description	Sample No.	Physical Characteristics							SHTL Class.	
							% Agg	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.		W. C.
828.6	0	10/14			Brown and Gray Gravelly Sandy Clay	1	17	4	15	26	38	38	19	20	
	2														
	4														
823.6	6														
	8														
818.6	10	12/15			Brown and Gray Gravelly Sandy Silt	2	15	10	15	31	29	23	9	13	
	12														
	14														
815.1	14	21/50			No Sample Recovered - Boulders										
813.6	16														
	18														
808.6	20														
	22														
806.1	22				Brown Silty Clay with Limestone Boulders Grayish-Brown Gravelly Clay TOP OF ROCK	3	17	4	2	28	49	38	18	19	
	24														
	26														
	28														
	30														
	32														
	34														
793.6			1.8	0.7	Shale, brownish-gray to gray, soft above 25.0', firm below, calcareous, interbedded with limestone, gray, dense fossiliferous, finely-crystalline (comprising 40% of the interval) in 0.2' to 0.4' intervals. Core loss 25%. BOTTOM OF BORING										
	24														
	26														
	28														
	30														
	32														
	34														
			4.5	0.5											
	24														
	26														
			3.4	1.6											
	24														
	26														



OHIO STATE HIGHWAY TESTING LABORATORY 100 WEST BROAD ST., COLUMBUS 23, OHIO			
STRUCTURE FOUNDATION INVESTIGATION			
BRIDGE NO. HAM-IR 71-			
PEDESTRIAN OVERPASS			
SITE HAM-IR 71-12.23			
PLAN AND PROFILE			
DRAWN BY	CHECKED BY	REVIEWED BY	DATE
R.P.W.	R.D.R.	G.P.H.	3/23/64

Appendix C. Boring Logs and Rock Core Photos

PROJECT: HAM-126-19.50		DRILLING FIRM / OPERATOR: NEAS / J. HODGES				DRILL RIG: CME 55 TRACK				STATION / OFFSET: 262+98, 95' RT.				EXPLORATION ID								
TYPE: BRIDGE		SAMPLING FIRM / LOGGER: HDR / D. MATCHISON				HAMMER: CME AUTOMATIC				ALIGNMENT: SR 126				B-001-0-24								
PID: 114652 SFN: 3118991		DRILLING METHOD: 3.25" HSA / NQ2				CALIBRATION DATE: 3/8/24				ELEVATION: 825.0 (MSL) EOB: 30.0 ft.				PAGE								
START: 9/25/24 END: 9/25/24		SAMPLING METHOD: SPT / ST / NQ2				ENERGY RATIO (%): 79.9				LAT / LONG: 39.226022, -84.370410				1 OF 1								
MATERIAL DESCRIPTION AND NOTES		ELEV.	DEPTHS		SPT/RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	HOLE SEALED		
		825.0								GR	CS	FS	SI	CL	LL	PL	PI					
VERY STIFF, BROWN MOTTLED GRAY, CLAY , "AND" SILT, LITTLE SAND, TRACE GRAVEL, DAMP @0.0' - 0.5': root hairs		820.0		1	2	5	15	67	SS-1	3.00	-	-	-	-	-	-	-	18	A-7-6 (V)			
					6																	
					3	4	6	19	67	SS-2	4.00	1	3	8	44	44	47	23	24		17	A-7-6 (15)
					4		8															
VERY STIFF, BROWN TO ORANGE-BROWN MOTTLED GRAY, CLAY , SOME SILT, LITTLE SAND, TRACE GRAVEL, NOTED BLACK IRON CONCRETIONS, DAMP @7.1' - 7.6': qu = 4,455 psf		815.0		5	3	4	16	67	SS-3	4.00	2	5	15	33	45	55	21	34	20		A-7-6 (19)	
					8																	
					7			92	ST-4	2.50	3	4	15	35	43	42	20	22	17		A-7-6 (13)	
					8																	
@9.0' - 9.5': auger grinding and chatter (limestone fragments)		807.5		9																		
					10	9	16	53	89	SS-5	4.00	-	-	-	-	-	-	-	12		A-6b (V)	
					11		24															
					12																	
VERY STIFF TO HARD, BROWN MOTTLED GRAY, SILTY CLAY , LITTLE GRAVEL, LITTLE SAND, DAMP @16.5': brown shale at bottom of SS-7		805.0		13	11	19	56	67	SS-6	4.00	12	7	12	36	33	33	17	16	11		A-6b (9)	
					14		23															
					15	5	9	39	89	SS-7	3.50	-	-	-	-	-	-	-	-		21	A-6b (V)
					16		20															
SHALE/LIMESTONE GRAY, SEVERELY WEATHERED, VERY WEAK.		805.0	TR	17																		
				18	48	50/4"	-	90	SS-8	-	-	-	-	-	-	-	-	-	9		Rock (V)	
				19		50/5"	-	60	SS-9	-	-	-	-	-	-	-	-	8	Rock (V)			
INTERBEDDED SHALE (71%) AND LIMESTONE (29%) JOINT AND BEDDING DISCONTINUITIES, FRACTURED TO HIGHLY FRACTURED, NARROW TO OPEN APERTURE WIDTH, SLICKENSIDED SURFACE, LAMINATED/SHEARED STRUCTURE, POOR SURFACE, RQD 7%, REC. 97%; SHALE GRAY, MODERATELY TO HIGHLY WEATHERED, VERY WEAK, LAMINATED TO THIN BEDDED, ARGILLACEOUS; LIMESTONE GRAY, MODERATELY TO HIGHLY WEATHERED, STRONG, VERY THIN TO THIN BEDDED. @20' - 20.8', 22.2' - 22.5', 24.2' - 24.5': Sc = 454 psi (combined point load test)				20																		
					21	13		100	NQ2-1												CORE	
					22																	
					23																	
					24																	
					25	7		100	NQ2-2											CORE		
					26																	
					27																	
					28																	
					29	0		87	NQ2-3												CORE	
NOTES: NONE		EOB																				
ABANDONMENT METHODS. MATERIALS. QUANTITIES: TREMIED 30 LB. BENTONITE GROUT: 30 GAL. WATER																						



STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT GDT - 2/3/25 13:51 - C:\P\WORKING\EA01D3184708\HAM-126-19.50.GPJ

PROJECT: HAM-126-19.50 TYPE: BRIDGE PID: 114652 SFN: 3118991 START: 9/24/24 END: 9/24/24		DRILLING FIRM / OPERATOR: NEAS / J. HODGES SAMPLING FIRM / LOGGER: HDR / A. BARATTA DRILLING METHOD: 3.25" HSA / NQ2 SAMPLING METHOD: SPT / NQ2		DRILL RIG: CME 55 TRACK HAMMER: CME AUTOMATIC CALIBRATION DATE: 3/8/24 ENERGY RATIO (%): 79.9		STATION / OFFSET: 264+10, 62' RT. ALIGNMENT: SR 126 ELEVATION: 818.0 (MSL) EOB: 21.8 ft. LAT / LONG: 39.226078, -84.370100		EXPLORATION ID B-002-0-24 PAGE 1 OF 1											
MATERIAL DESCRIPTION AND NOTES		ELEV. 818.0	DEPTHS	SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG				ODOT CLASS (GI)	HOLE SEALED
									GR	CS	FS	SI	CL	LL	PL	PI	WC		
MEDIUM STIFF, BROWN, SILTY CLAY , SOME STONE FRAGMENTS, LITTLE SAND, TRACE ROOTS, MOIST		815.5	1	0 2 3	7	56	SS-1	0.50	23	9	9	30	29	37	19	18	21	A-6b (8)	
VERY STIFF TO HARD, BROWN TRACE GRAY AND ORANGE, CLAY , SOME SILT, LITTLE STONE FRAGMENTS, LITTLE SAND, DAMP			2																
			3	4 9 14	31	83	SS-2	4.5+	-	-	-	-	-	-	-	-	12	A-7-6 (V)	
			4																
			5	13 14 7	28	61	SS-3	4.50	16	5	7	31	41	46	20	26	15	A-7-6 (15)	
			6																
			7																
		809.0	8	3 6 10	21	78	SS-4	4.50	-	-	-	-	-	-	-	-	12	A-7-6 (V)	
DENSE, GRAY, STONE FRAGMENTS TRACE SAND, TRACE SILT AND CLAY, WEATHERED LIMESTONE FRAGMENTS, DRY		806.5	9	30 13 23	48	17	SS-5	-	88	7	3	-	2	-	NP	NP	NP	1	A-1-a (0)
			10																
INTERBEDDED SHALE (53%) AND LIMESTONE (47%) JOINT AND BEDDING DISCONTINUITIES, FRACTURED TO HIGHLY FRACTURED, NARROW TO OPEN APERTURE WIDTH, SLICKENSIDED TO SLIGHTLY ROUGH SURFACE, DISINTEGRATED STRUCTURE, VERY POOR TO POOR SURFACE, RQD 13%, REC. 96%; SHALE GRAY, SEVERELY TO HIGHLY WEATHERED, VERY WEAK, LAMINATED TO THIN BEDDED, ARGILLACEOUS, CALCAREOUS; LIMESTONE GRAY, MODERATELY WEATHERED, VERY STRONG, VERY THIN TO THIN BEDDED. @14.2' - 14.5': qu = 16,183 psi			11																
			12	50/3" 0		67 79	SS-6 NQ2-1										0	Rock (V) CORE	
			13																
			14																
			15	20		100	NQ2-2											CORE	
			16																
			17																
			18																
			19																
			20	10		96	NQ2-3											CORE	
		796.2	21																
			EOB																
NOTES: BORING PERFORMED IN DITCH CONTAINING HYDROPHILIC VEGETATION. RAIN OCCURRED OVERNIGHT, PRIOR TO DRILLING.																			
ABANDONMENT METHODS, MATERIALS, QUANTITIES: TREMIED 40 LB. BENTONITE GROUT; 55 GAL. WATER																			



B-002-0-24



Run #	Depth (ft)		Recovery		RQD	
NQ2-1	11.8	13.0	11 in. / 14 in.	79%	0 in. / 14 in.	0%
NQ2-2	13.0	17.5	54 in. / 54 in.	100%	11 in. / 54 in.	20%
NQ2-3	17.5	21.8	50 in. / 52 in.	96%	5 in. / 52 in.	10%

HAM-126-19.50 PID 114652

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT GDT - 2/3/25 13:51 - C:\P\WORKING\EA\ST01D3184708\HAM-126-19.50.GPJ

PROJECT: HAM-126-19.50 TYPE: BRIDGE PID: 114652 SFN: 3118991 START: 9/26/24 END: 9/26/24		DRILLING FIRM / OPERATOR: NEAS / J. HODGES SAMPLING FIRM / LOGGER: HDR / A. BARATTA DRILLING METHOD: 3.25" HSA / NQ2 SAMPLING METHOD: SPT / ST / NQ2		DRILL RIG: CME 55 TRACK HAMMER: CME AUTOMATIC CALIBRATION DATE: 3/8/24 ENERGY RATIO (%): 79.9		STATION / OFFSET: 264+25, 58' LT. ALIGNMENT: SR 126 ELEVATION: 822.0 (MSL) EOB: 24.5 ft. LAT / LONG: 39.226401, -84.369991		EXPLORATION ID B-003-0-24 PAGE 1 OF 1											
MATERIAL DESCRIPTION AND NOTES		ELEV. 822.0	DEPTHS	SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	HOLE SEALED
TOPSOIL (1")		821.9	1																
VERY STIFF TO HARD, BROWN TRACE GRAY, CLAY , SOME SILT, LITTLE SAND, TRACE STONE FRAGMENTS, DAMP @2.5' - 3.0': qu = 5,076 psf		818.5	2			83	ST-1	4.5+	2	6	14	29	49	54	23	31	21	A-7-6 (19)	
VERY STIFF TO HARD, BROWN TRACE GRAY, SILTY CLAY , SOME STONE FRAGMENTS, LITTLE SAND, DAMP @6.0': no recovery			3	7	19	48	89	SS-2	3.00	23	8	11	30	28	33	17	16	12	A-6b (7)
			4	11	10														
			5	11	10	32	0	SS-3	-	-	-	-	-	-	-	-	-		
			6	11	10														
			7	11	10														
		813.5	8	4	8														
VERY STIFF, BROWN TRACE ORANGE, SILTY CLAY , LITTLE SAND, TRACE STONE FRAGMENTS, DAMP			9	4	8	27	100	SS-4	4.5+	2	3	12	43	40	32	16	16	14	A-6b (10)
		811.0	10																
VERY STIFF, BROWN TRACE ORANGE, CLAY , SOME SILT, LITTLE SAND, TRACE STONE FRAGMENTS, DAMP		810.1	11				100	ST-5	4.50	9	4	9	35	43	41	20	21	16	A-7-6 (13)
SHALE/LIMESTONE GRAY, SEVERELY WEATHERED, VERY WEAK.		808.5	12	21	50/3"	-	67	SS-6	-	-	-	-	-	-	-	-	11	Rock (V)	
SHALE GRAY, SEVERELY WEATHERED, VERY WEAK.		807.5	13	25	50/5"	-	82	SS-7	-	-	-	-	-	-	-	-	11	Rock (V)	
INTERBEDDED SHALE (69%) AND LIMESTONE (31%) JOINT AND BEDDING DISCONTINUITIES, FRACTURED TO HIGHLY FRACTURED, NARROW TO OPEN APERTURE WIDTH, SLICKENSIDED TO SLIGHTLY ROUGH SURFACE, BLOCKY/DISTURBED/SEAMY STRUCTURE, POOR TO FAIR SURFACE, RQD 37%, REC. 93%; SHALE GRAY, MODERATELY TO HIGHLY WEATHERED, VERY WEAK, VERY THIN TO THIN BEDDED, ARGILLACEOUS, CALCAREOUS; LIMESTONE GRAY, MODERATELY WEATHERED, VERY STRONG, VERY THIN TO THIN BEDDED.			14																
			15																
			16																
			17																
			18	33			94	NQ2-1										CORE	
			19																
			20																
			21																
			22																
			23	45			91	NQ2-2										CORE	
		797.5	24																
			EOB																
NOTES: NONE																			
ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 25 LB. BENTONITE CHIPS; TREMIED 25 LB. BENTONITE GROUT; 25 GAL. WATER																			



Run #	Depth (ft)		Recovery		RQD	
NQ2-1	14.5	21.8	82 in. / 87 in.	94%	29 in. / 87 in.	33%
NQ2-2	21.8	24.5	30 in. / 33 in.	91%	15 in. / 33 in.	45%

HAM-126-19.50 PID 114652

PROJECT: <u>HAM-126-19.50</u>	DRILLING FIRM / OPERATOR: <u>NEAS / J. HODGES</u>	DRILL RIG: <u>CME 55 TRACK</u>	STATION / OFFSET: <u>262+85, 84' LT.</u>	EXPLORATION ID <u>B-004-0-24</u>
TYPE: <u>BRIDGE</u>	SAMPLING FIRM / LOGGER: <u>HDR / A. BARATTA</u>	HAMMER: <u>CME AUTOMATIC</u>	ALIGNMENT: <u>SR 126</u>	
PID: <u>114652</u> SFN: <u>3118991</u>	DRILLING METHOD: <u>3.25" HSA / NQ2</u>	CALIBRATION DATE: <u>3/8/24</u>	ELEVATION: <u>823.0 (MSL)</u> EOB: <u>23.3 ft.</u>	PAGE 1 OF 1
START: <u>9/26/24</u> END: <u>9/26/24</u>	SAMPLING METHOD: <u>SPT / ST / NQ2</u>	ENERGY RATIO (%): <u>79.9</u>	LAT / LONG: <u>39.226497, -84.370498</u>	

[illegible]

NOTES: NONE



B-004-0-24



Run #	Depth (ft)		Recovery		RQD	
NQ2-1	13.3	18.8	54 in. / 66 in.	82%	15 in. / 66 in.	23%
NQ2-2	18.8	23.3	54 in. / 54 in.	100%	5 in. / 54 in.	9%

HAM-126-19.50 PID 114652

Appendix D. Laboratory Testing

Unconfined Compression Test on Soil (ASTM D 2166)

Unconfined Compressive Strength of Cohesive Soil (ASTM D2166)

(Project: HAM-126-19.50, Boring Location: B-001-0-24, ST-4, Depth: 7.1-7.6 ft)

Tested Date: 11/4/2024

Specimen Properties

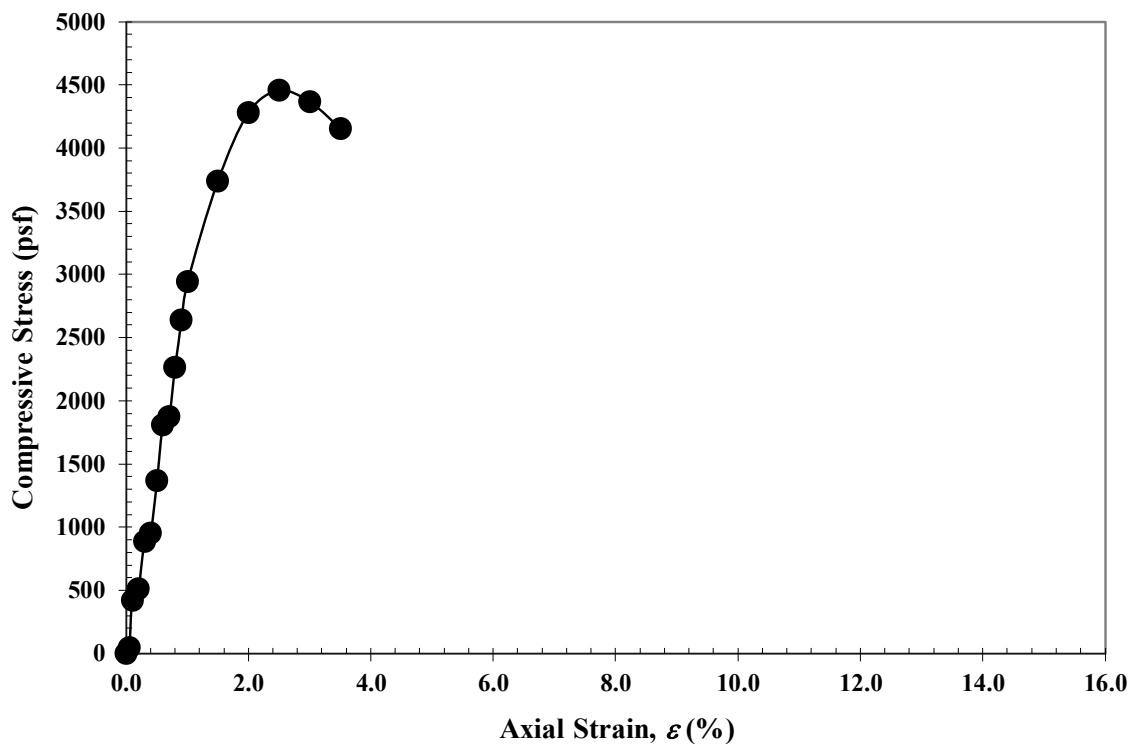
Average Dia., D_{avg} (in):	2.88
Average Height, H_{avg} (in):	5.75
Area, A (in ²):	6.49
Volume, V (in ³):	37.36
Wet Mass of Specimen (lb):	2.8
Moisture Content (%):	18.0
Dry Mass of Specimen (lb):	2.4
Wet Unit Weight, γ (lb/ft ³):	129.2
Dry Unit Weight, γ_d (lb/ft ³):	109.5

Final Specimen Figure



Results

Unconfined Compressive Strength (psf):	4455
Strain (%):	2.5



Notes: Very stiff, brown mottled with gray and orangish brown, CLAY, some silt, little sand, trace gravel, damp.

Unconfined Compressive Strength of Cohesive Soil (ASTM D2166)

(Project: HAM-126-19.50, Boring Location: B-003-0-24, ST-1, Depth: 2.5-3.0 ft)

Tested Date: 11/4/2024

Specimen Properties

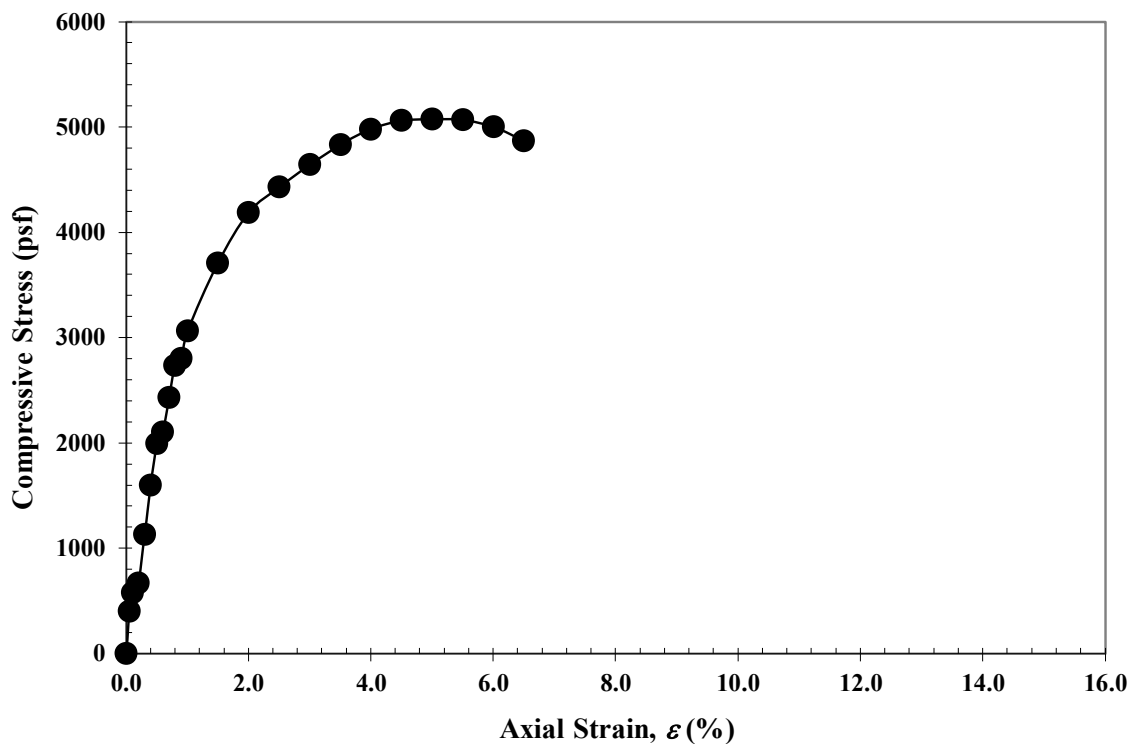
Average Dia., D_{avg} (in):	2.87
Average Height, H_{avg} (in):	5.74
Area, A (in ²):	6.47
Volume, V (in ³):	37.14
Wet Mass of Specimen (lb):	2.8
Moisture Content (%):	17.9
Dry Mass of Specimen (lb):	2.4
Wet Unit Weight, γ (lb/ft ³):	131.7
Dry Unit Weight, γ_d (lb/ft ³):	111.7

Final Specimen Figure



Results

Unconfined Compressive Strength (psf):	5076
Strain (%):	5.0



Notes: Very stiff, brown and gray, CLAY, some silt, little sand, trace gravel, damp.

One-Dimensional Consolidation Test (ASTM D 2435)

Consolidation Test

Project Name: HAM-126-19.50

Source: B-001-0-24 ST-4 (7.7'-7.8')

Description: Very stiff, brown mottled with orangish brown and gray, CLAY,
some silt, little sand, trace gravel, damp.

Prepared by: LR

Checked by: ZM

Date: 11/18/2024

Test Specification: ASTM D 2435

Initial Void Ratio: 0.531

Initial Bulk Unit Weight (lb/ft³): 130

In-situ Vertical Effective Stress (psf): 924

Dry Unit Weight (lb/ft³): 110

Compression and Swelling Index

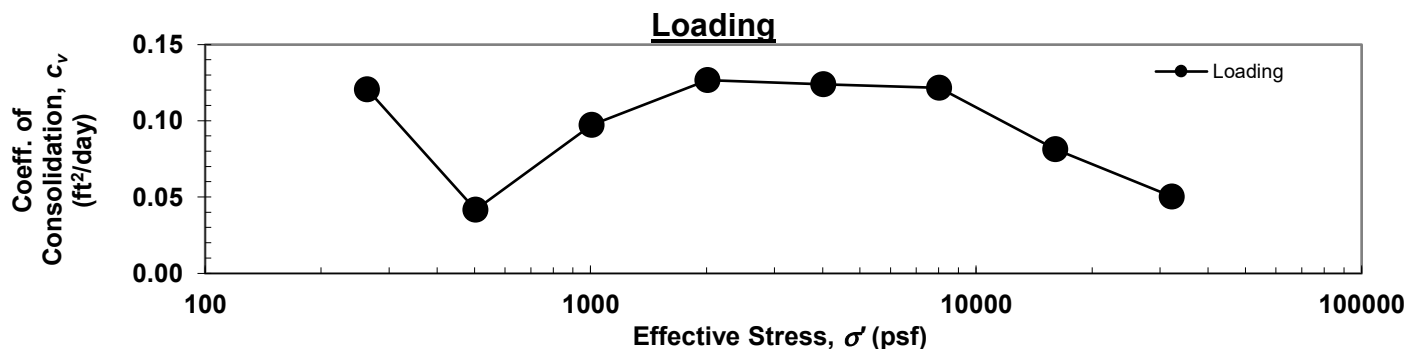
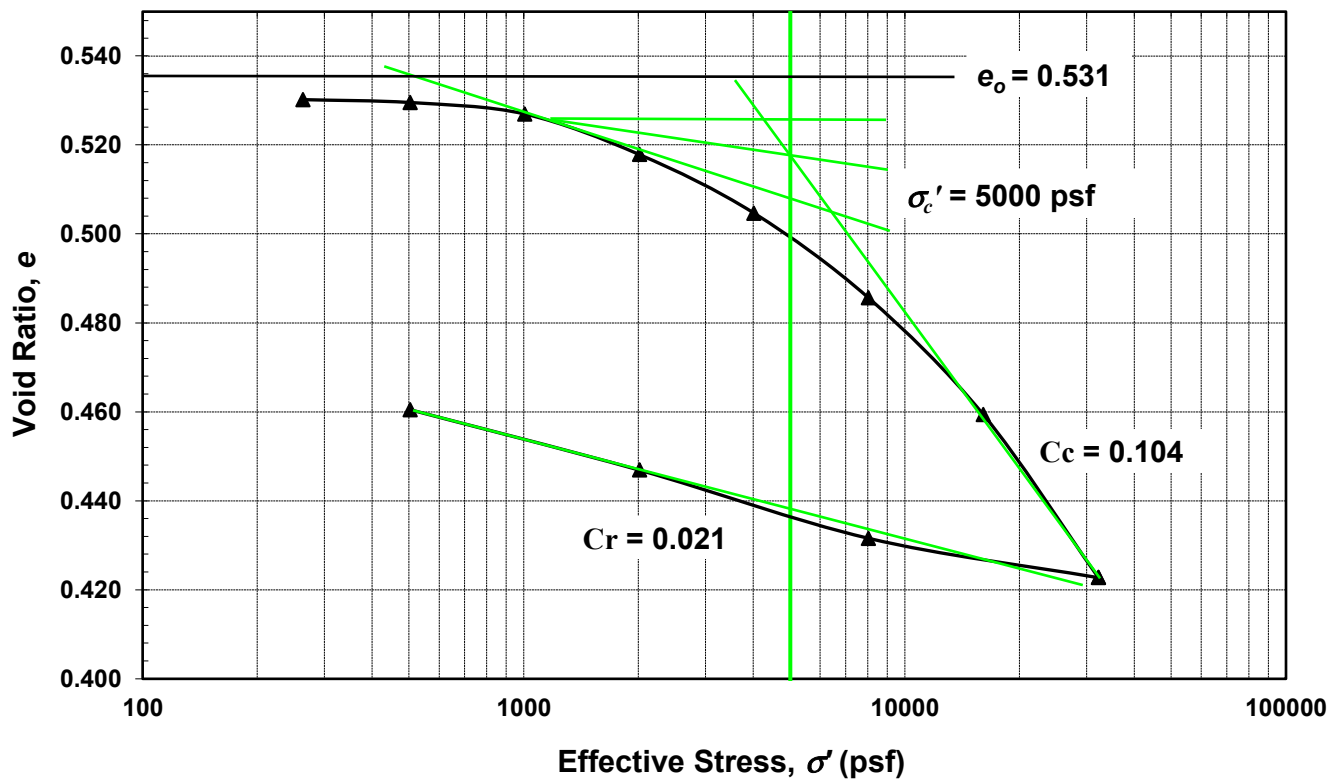
Compression Index (C_c): 0.104

Preconsolidation Pressure (σ'_c)(psf): 5000

Recompression Index (C_r): 0.021

Over-Consolidation Ratio (OCR): 5.4

Consolidation Curve



Consolidation Test

Project Name: HAM-126-19.50

Source: B-003-0-24 ST-1 (2.2'-2.3')

Description: Hard, brown and gray, CLAY, some silt, little sand, trace gravel, damp.

Prepared by: LR

Checked by: ZM

Date: 11/18/2024

Test Specification: ASTM D 2435

Initial Void Ratio: 0.628

Initial Bulk Unit Weight (lb/ft³): 127

In-situ Vertical Effective Stress(psf): 264

Dry Unit Weight (lb/ft³): 104

Compression and Swelling Index

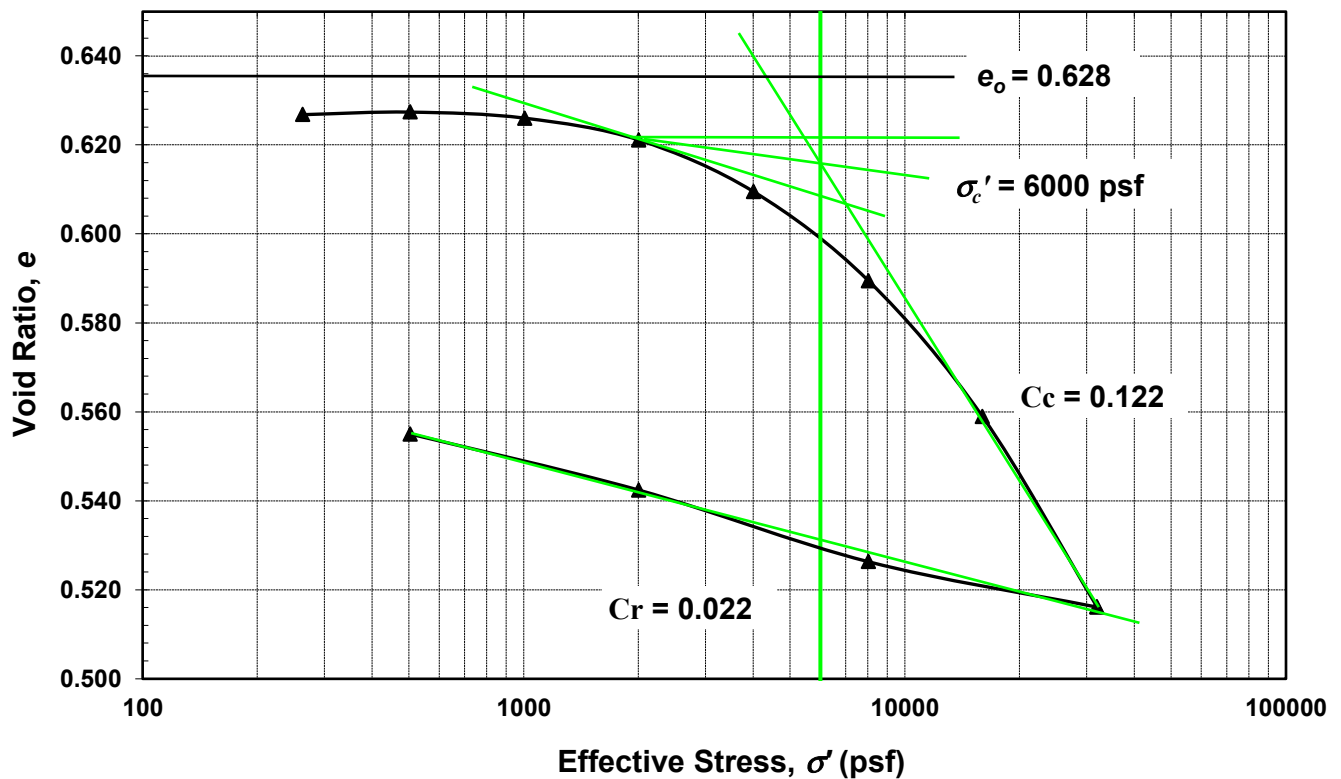
Compression Index (C_c): 0.122

Preconsolidation Pressure (σ'_c)(psf): 6000

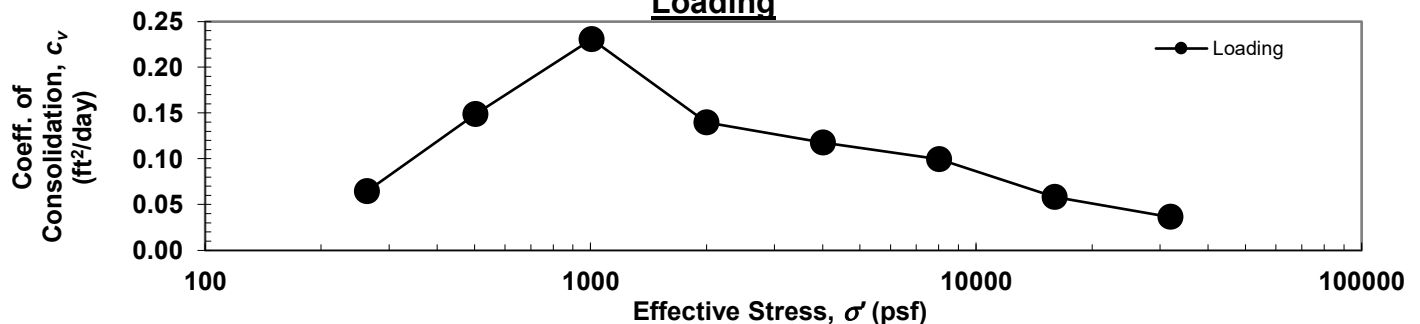
Recompression Index (C_r): 0.022

Over-Consolidation Ratio (OCR): 22.7

Consolidation Curve



Loading



Unconfined Compression Test of Rock (ASTM D 7012)

Unconfined Compressive Strength of Rock Core (ASTM D7012 Method C)

(Project: HAM-126-19.50, Boring Location: B-002-0-24, NQ2-2, Depth: 14.2-14.5ft)

Tested Date: 11/7/2024

Specimen Properties

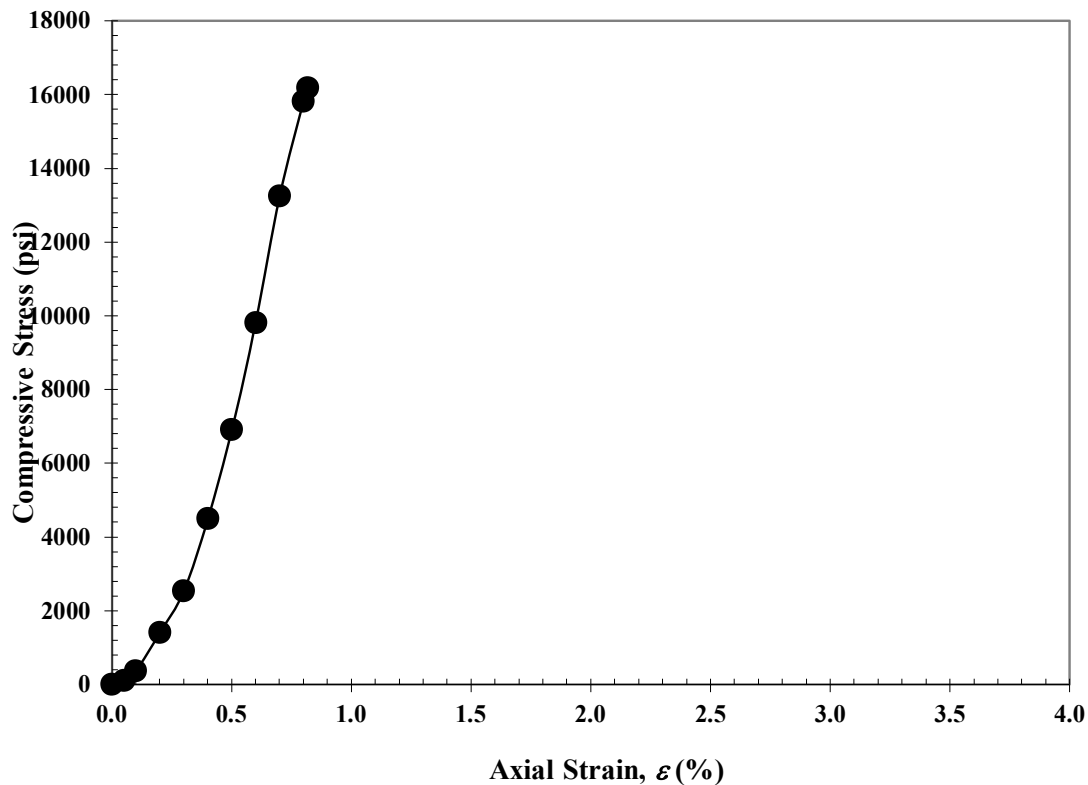
Average Dia., D_{avg} (in):	1.98
Average Height H_{avg} (in):	3.79
Length to Diameter Ratio:	1.92
Area, A (in ²):	3.07
Volume, V (in ³):	11.65
Wet Mass of Specimen (lb):	1.1
Moisture Content (%):	0.2
Dry Mass of Specimen (lb):	1.1
Wet Unit Weight, γ (lb/ft ³):	168.1
Dry Unit Weight, γ_d (lb/ft ³):	167.8

Final Specimen Figure



Results

Unconfined Compressive Strength (psi):	16183	112	(MPa)
Strain (%):	0.8		



Notes: Limestone, gray, slightly weathered, very strong. Please note that this specimen does not meet the L/D ratio of D7012 and the results reported may differ from a specimen that does meet the L/D requirements of D7012.

Point Load Strength Index of Rock (ASTM D 5731)

POINT LOAD TEST DATA (ASTM D5731)

Project Name: <u>HAM-126-19.50</u>	Project Number: <u>114652</u>
Boring Number: <u>B-001-0-24</u>	Sample Number: <u>NQ2-1 to NQ2-2</u>
Tested By: <u>LR</u>	Test Date: <u>11/4/2024</u>
Test Device: <u>Wille Geotechnik LP-4500</u>	Serial Number: <u>2510A971409</u>
Readout: <u>LEO 2 digital Manometer</u>	Calibrated Date: <u>1/8/2024</u>
Moisture Content %: <u>10.07%</u>	

Sample Details: Shale, gray, highly to moderately weathered, very weak, fissile. Tested in as received wrapped moisture condition.

Specimen Number	Test Type	Width (w), mm	D (De), mm	Length (L), mm	Load (P), kN	De ² , mm ²	De, mm	Is, Mpa	F	Is ₍₅₀₎ , MPa
1	a	50.14	29.05		0.14	1855	43.06971	0.08	0.935	0.07
2	a	50.02	20.77		0.23	1323	36.37307	0.17	0.867	0.15
3	a	48.34	27.29		0.2	1680	40.9878	0.12	0.914	0.11
4	a	46.96	19.36		0.23	1158	34.0294	0.20	0.841	0.17
5	a	49.6	19.64		0.26	1240	35.21363	0.21	0.854	0.18
6	a	49.78	20.96		0.26	1328	36.44173	0.20	0.867	0.17
7	a	49.57	18.44		0.2	1164	34.11744	0.17	0.842	0.14
8	a	49.87	21.71		0.17	1379	37.13489	0.12	0.875	0.11
9	a	50.02	30.28		0.31	1928	43.909	0.16	0.943	0.15
10	a	49.67	22.69		0.17	1435	37.88139	0.12	0.883	0.11

d = diametral

a = axial

b = block

i = irregular lump

⊥ = perpendicular to plane of weakness

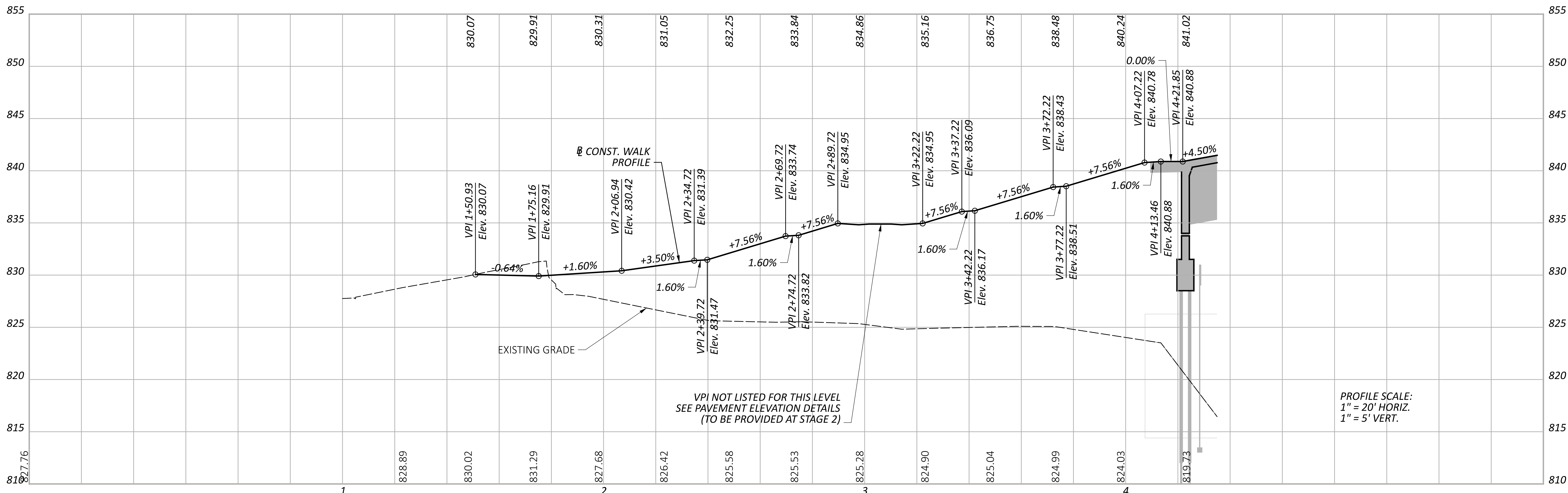
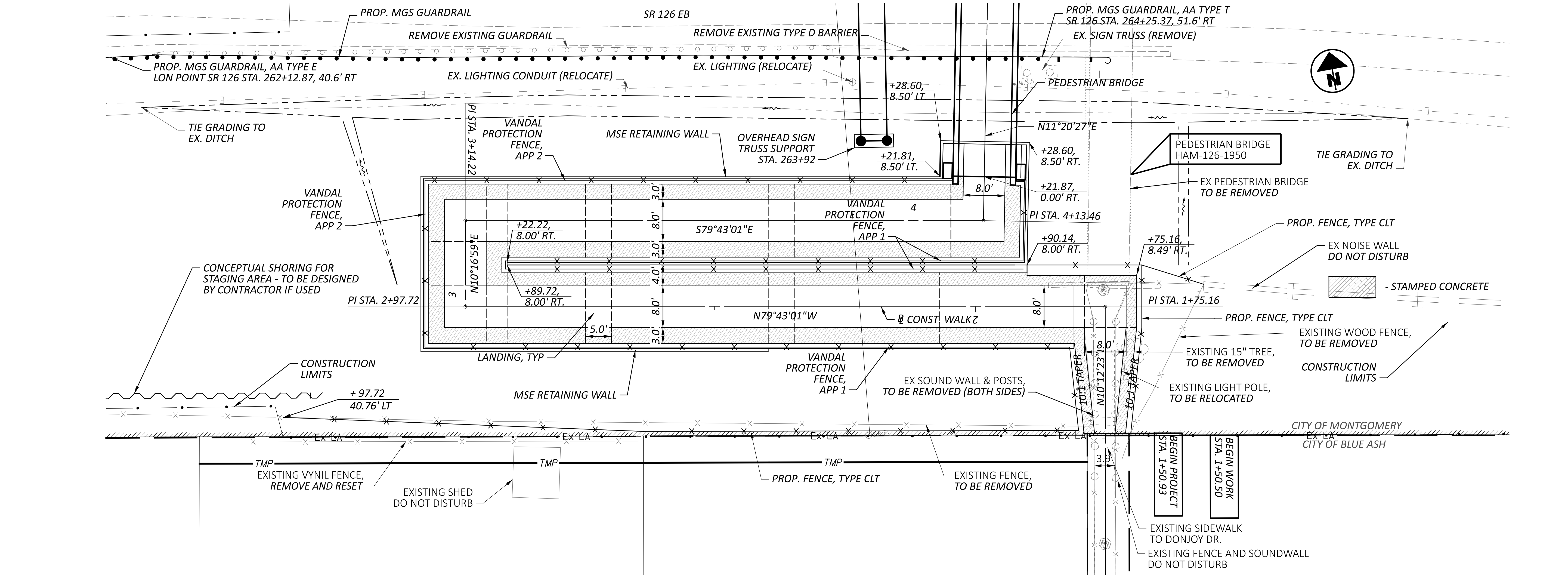
// = parallel to plane of weakness

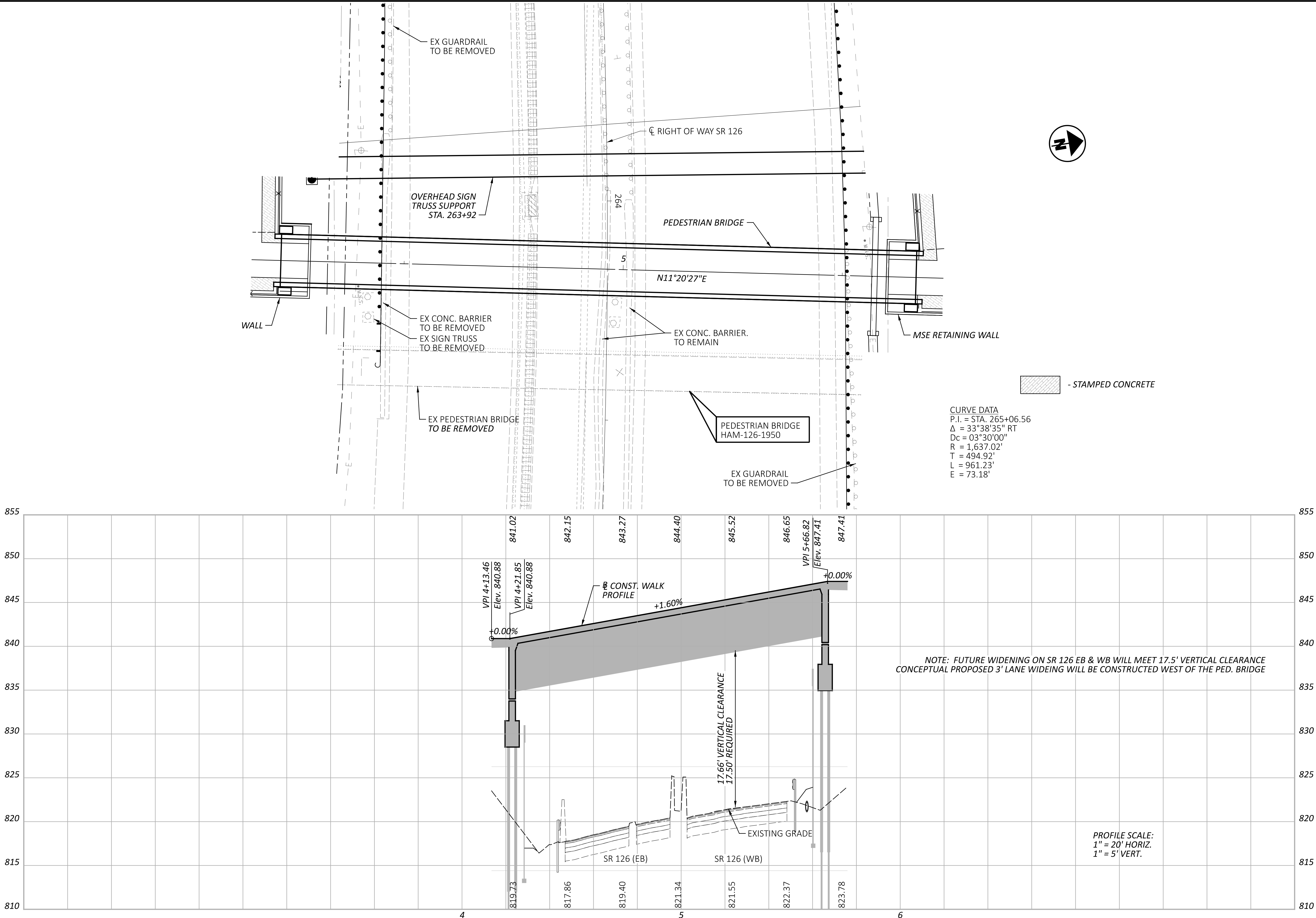
Statistics	
Mean Is ₍₅₀₎ ⊥	0.136
Mean Is ₍₅₀₎ //	
Ia ₍₅₀₎ //	

Strength Conversion Factor, K: 23
Uniaxial compressive Strength, Sc: 3.128 Mpa

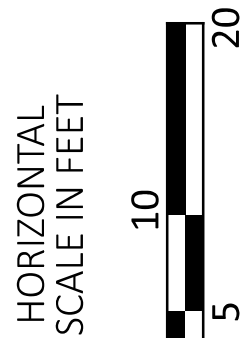
Appendix E. Analyses

Design Profile

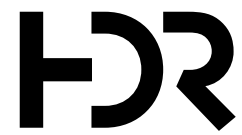




PLAN AND PROFILE
STA. 4+30.00 TO STA. 5+60.00



DESIGN AGENCY



DESIGNER

MJL

REVIEWER

KF 09/20/24

PROJECT ID

114652

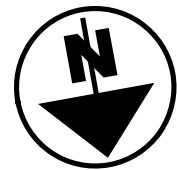
SHEET

P.9

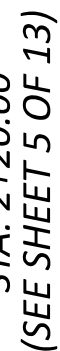
TOTAL

32





PLAN



ELEVATION (1 OF 2)

BM SV3 (MAGS)	STA. 264+37.59	ELEV. 822.12	OFFSET 313.75' RT.
BM T6 (IPINS)	STA. 262+51.26	ELEV. 818.95	OFFSET 2.14' LT.

FOR ADDITIONAL BENCHMARK INFORMATION, SEE ROADWAY PLANS.

NOTES

1. EARTHWORK LIMITS SHOWN ARE APPROXIMATE. ACTUAL SLOPES SHALL CONFORM TO PLAN CROSS SECTIONS.
2. WALL ELEVATION SHOWN LOOKING AT BACK OF WALL.

LEGEND

-  - STAMPED CONCRETE
 - EX. SIGN TRUSS REMOVAL
 - PROJECT BORING LOCATION

WALL PLAN AND ELEVATION (1 OF 2)
WALL 001
ALONG SOUTH APPROACH

SFN

N/A

DESIGN AGENCY



9999 CARVER ROAD
SUITE 210
CINCINNATI, OH 45242
513.984.7500

DESIGNER	CHECKER
RBK	JML

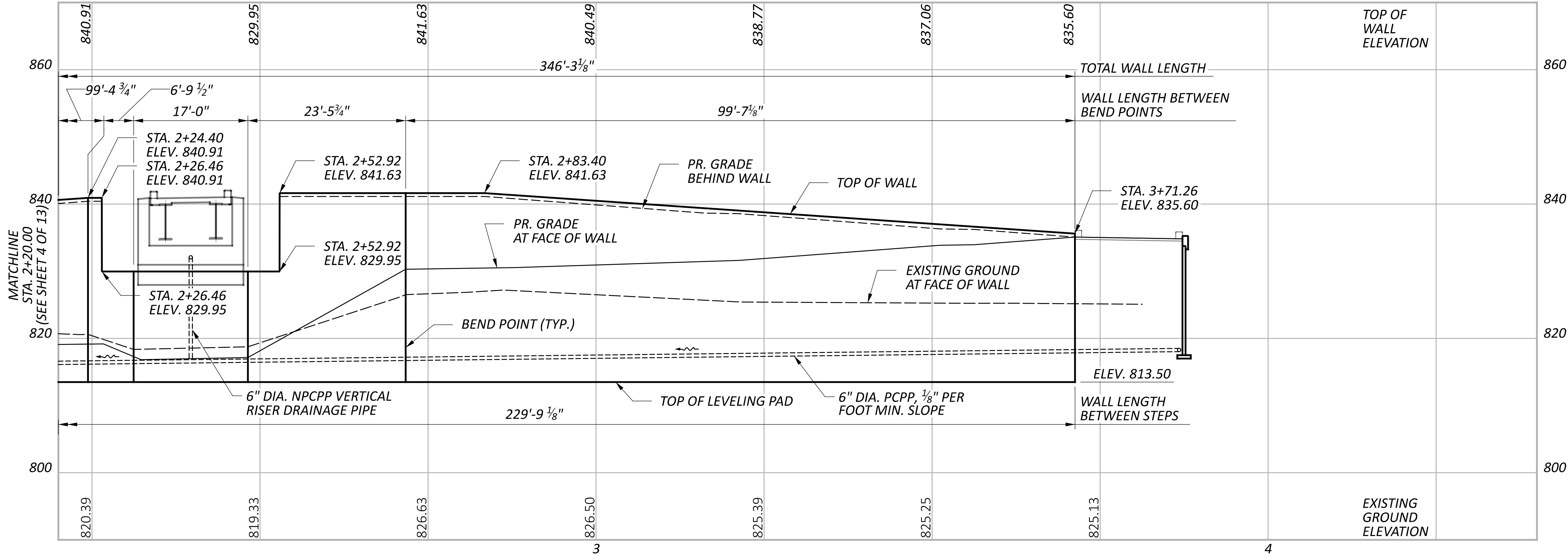
REVIEWER

JMS 9/18/24

PROJECT ID
114652

SUBSET	TOTAL
4	1

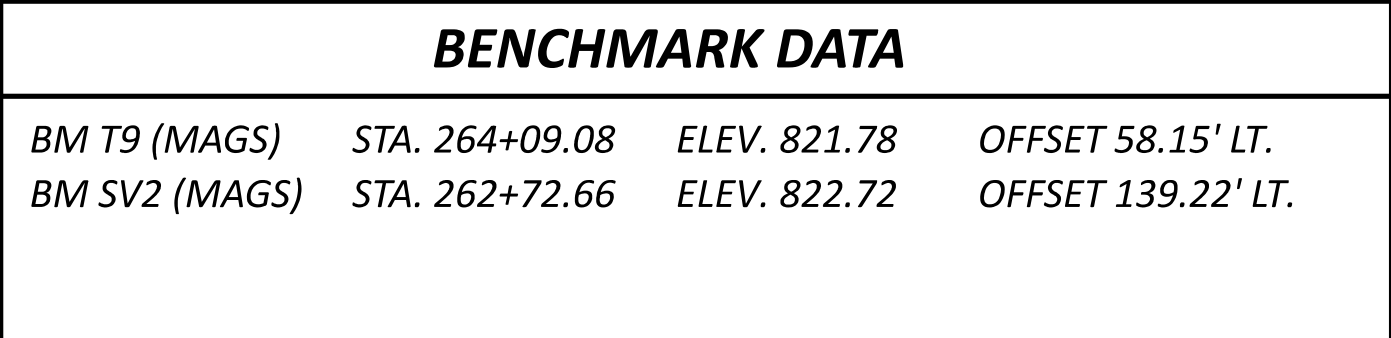
SHEET	TOTAL
P.25	3



ELEVATION (2 OF 2)

WALL PLAN AND ELEVATION (2 OF 2)
WALL 001
ALONG SOUTH APPROACH

SFN		N/A
DESIGN AGENCY		 9999 CARVER ROAD SUITE 210 CINCINNATI, OH 45242 513.984.7500
DESIGNER	CHECKER	
RBK	JML	
REVIEWER		
JMS		9/18/24
PROJECT ID		114652
SUBSET	TOTAL	
5	13	
SHEET	TOTAL	
P.26	32	

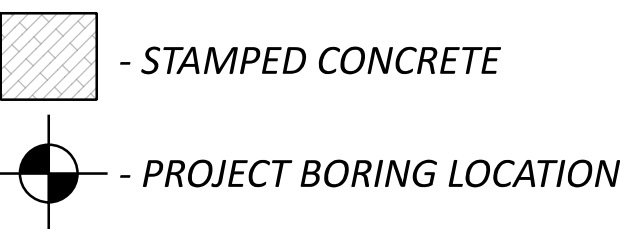


FOR ADDITIONAL BENCHMARK INFORMATION, SEE ROADWAY PLANS.

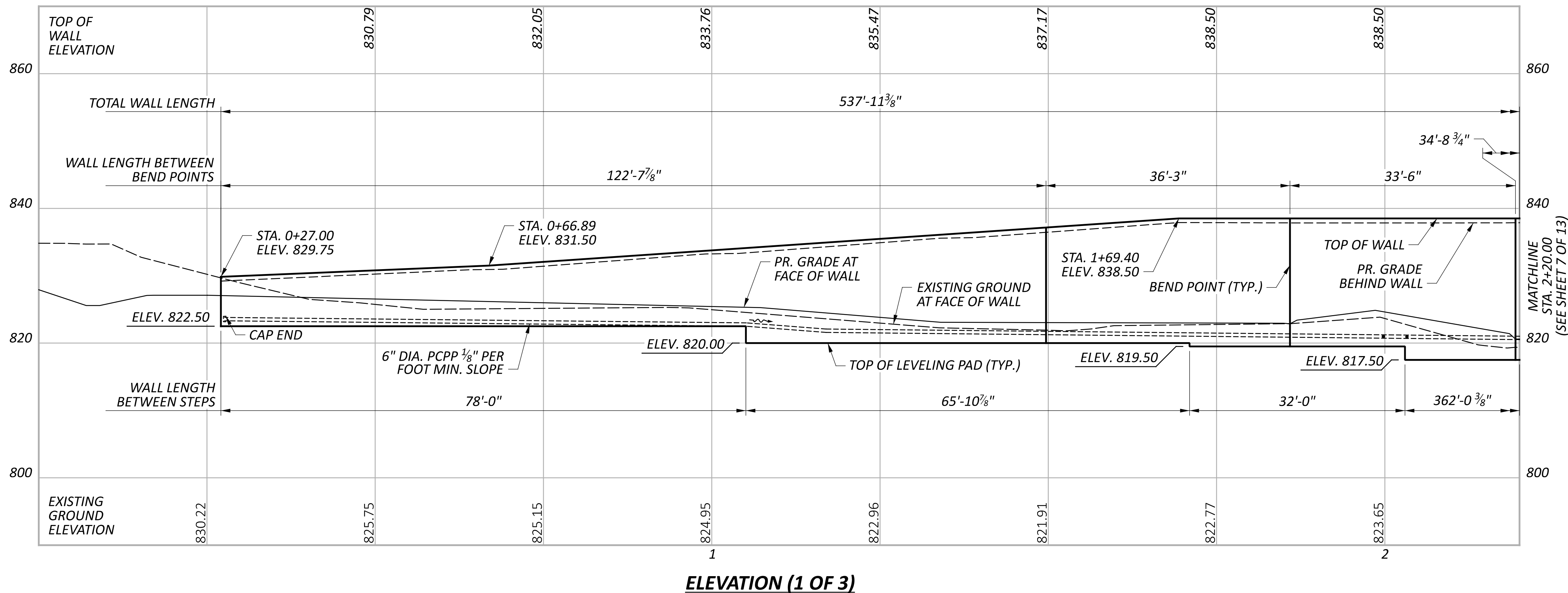
NOTES

1. EARTHWORK LIMITS SHOWN ARE APPROXIMATE. ACTUAL SLOPES SHALL CONFORM TO PLAN CROSS SECTIONS.

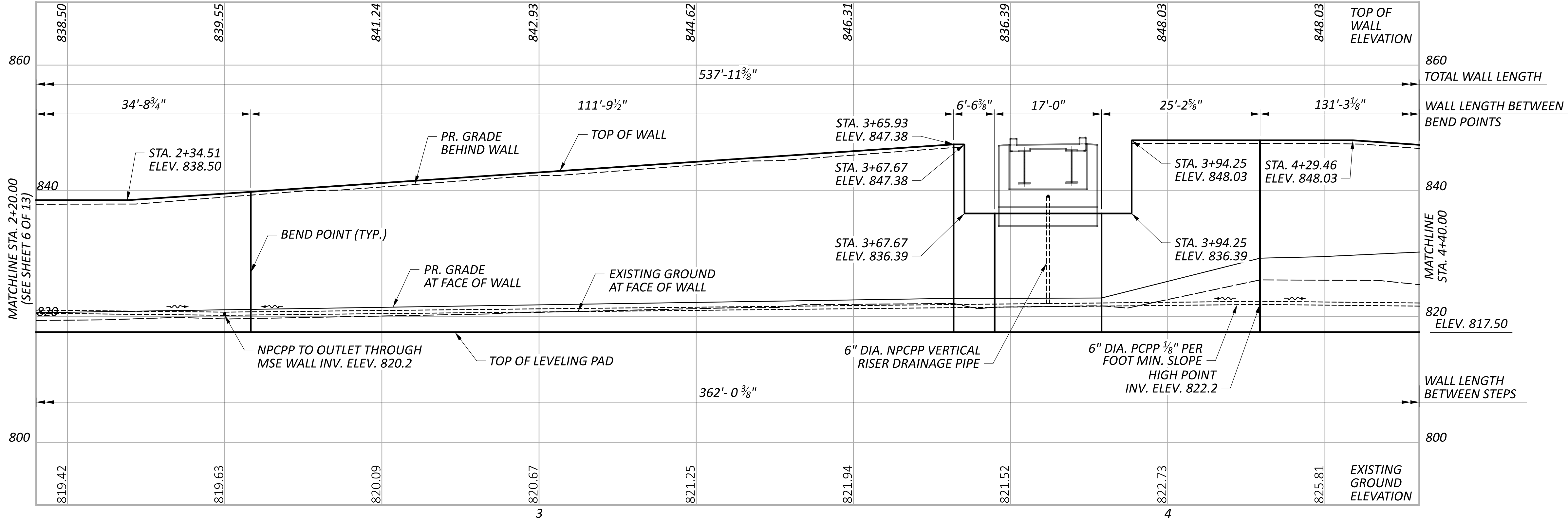
LEGEND



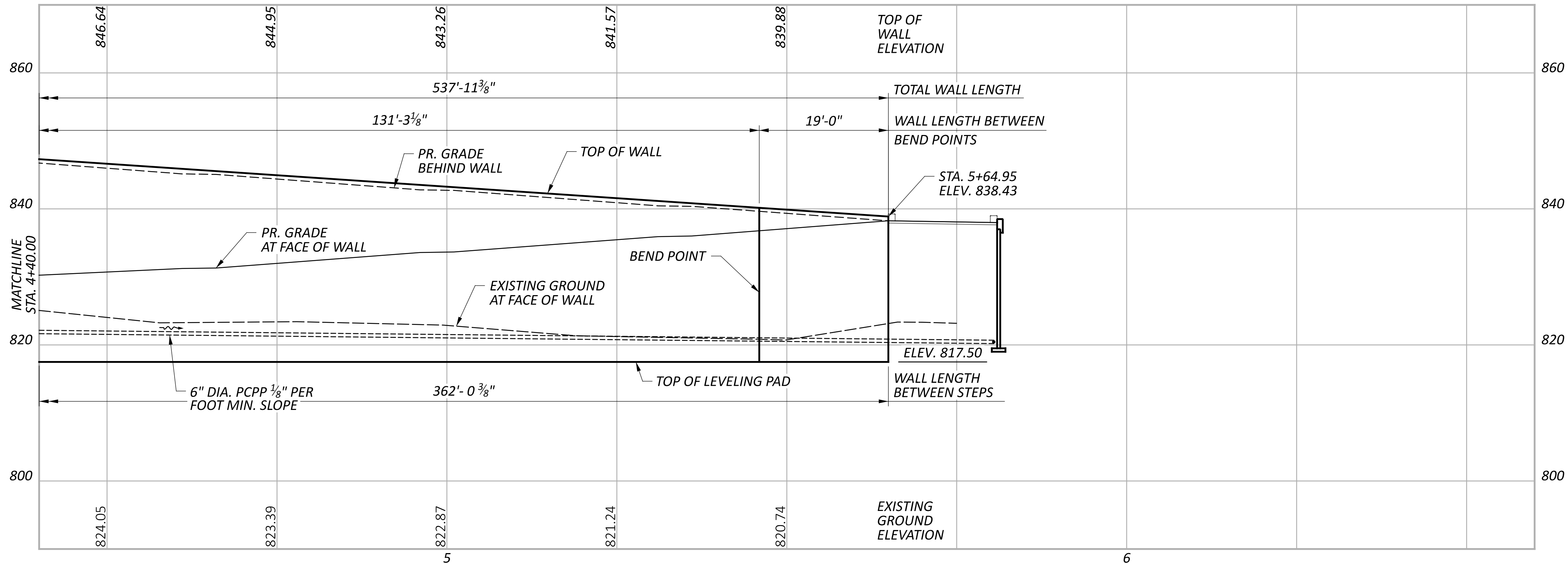
WALL PLAN AND ELEVATION (1 OF 2)
WALL 002
ALONG NORTH APPROACH



SFN	
N/A	
DESIGN AGENCY	
	
9999 CARVER ROAD SUITE 210 CINCINNATI, OH 45242 513.984.7500	
DESIGNER	CHECKER
RBK	JML
REVIEWER	
JMS 9/18/24	
PROJECT ID	
114652	
SUBSET	TOTAL
6	13
SHEET	TOTAL
P.27	32

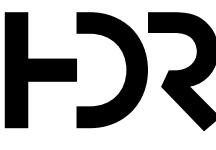


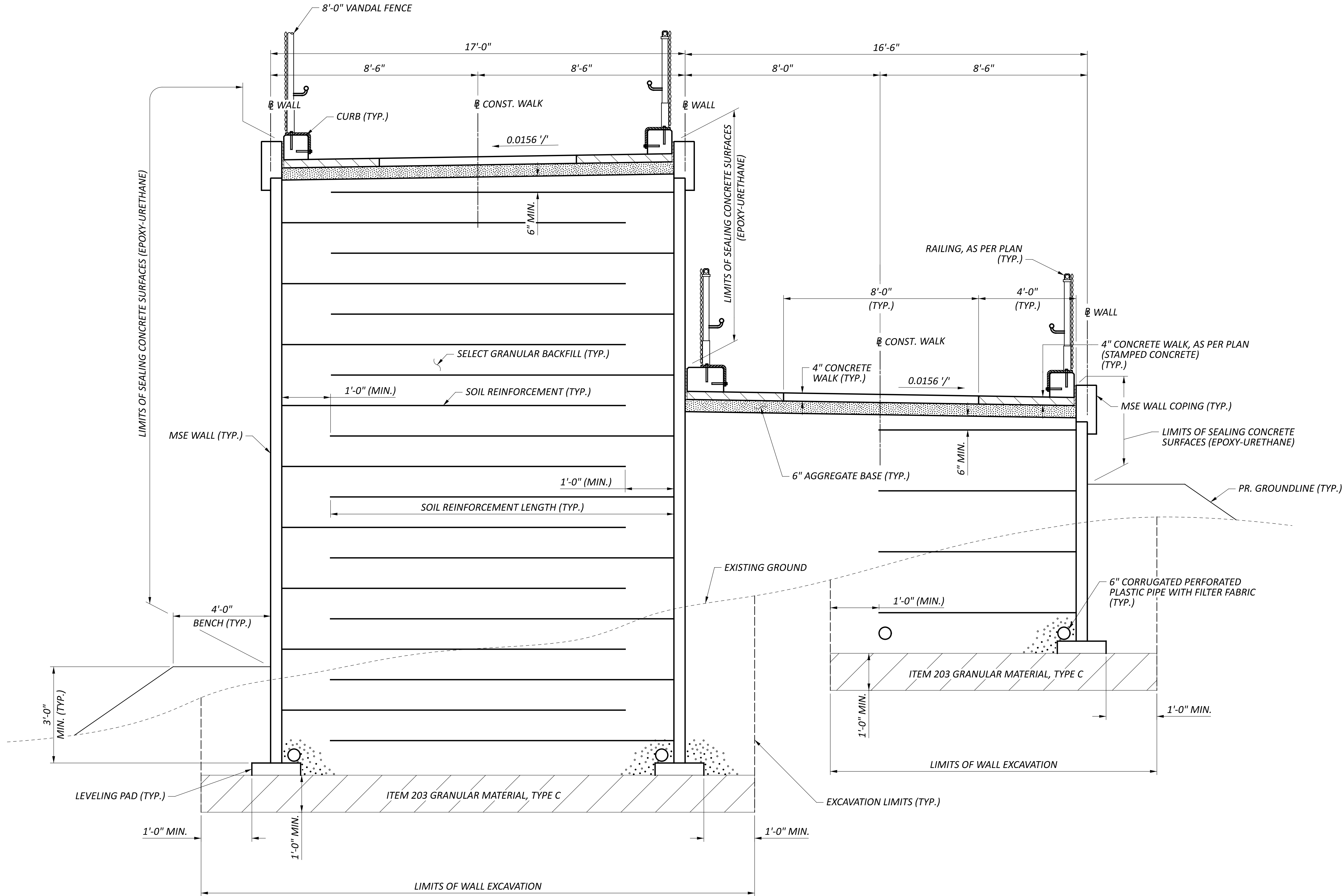
ELEVATION (2 OF 3)



ELEVATION (3 OF 3)

WALL PLAN AND ELEVATION (2 OF 2)
WALL 002
ALONG NORTH APPROACH

SFN	N/A
DESIGN AGENCY	
DESIGNER	CHECKER
RBK	JML
REVIEWER	
JMS	9/18/24
PROJECT ID	114652
SUBSET	TOTAL
7	13
SHEET	TOTAL
P.28	32



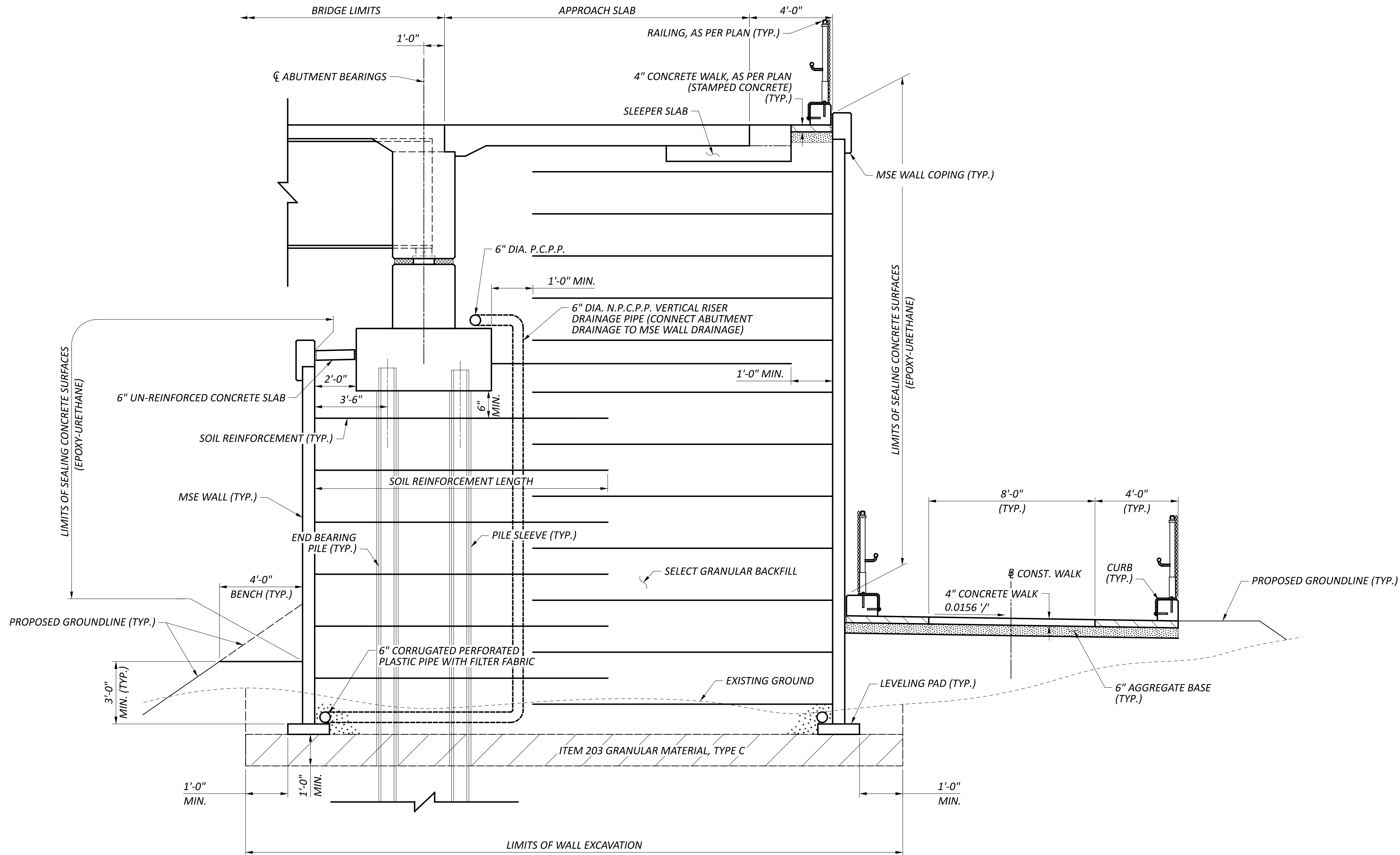
TYPICAL MSE WALL SECTION

NOTES:

1. FOR ADDITIONAL INFORMATION ON THE PATH TYPICAL SECTION, SEE THE ROADWAY PLAN SHEETS.

MSE WALL DETAILS (1 OF 3)
WALL 001 AND 002
ALONG SOUTH AND NORTH APPROACH

SFN	N/A
DESIGN AGENCY	HDR
9999 CARVER ROAD SUITE 210 CINCINNATI, OH 45242 513.984.7500	
DESIGNER	CHECKER
RBK	JML
REVIEWER	
JMS	9/18/24
PROJECT ID	114652
SUBSET	TOTAL
10	13
SHEET	TOTAL
P.29	32



TYPICAL MSE WALL SECTION AT BRIDGE ABUTMENT

NOTES:

- FOR ADDITIONAL INFORMATION ON THE PATH TYPICAL SECTION, SEE THE ROADWAY PLAN SHEETS.
- FOR ADDITIONAL INFORMATION ON THE BRIDGE ABUTMENT SECTION, SEE THE BRIDGE PLAN SHEETS.
- 6" DIA. N.P.C.P.P. VERTICAL RISER DRAINAGE PIPE SHALL BE CAPPED TO KEEP OUT DEBRIS. CAP TO THEN BE REMOVED WHEN CONNECTING TO ABUTMENT DRAINAGE SYSTEM.

SFN

N/A

DESIGN AGENCY

9999 CARVER ROAD
SUITE 210
CINCINNATI, OH 45242
513.984.7500

DESIGNER

RBK

CHECKER

REVIEWER

PROJECT ID

114652

SUBSET

11

TOTAL

13

SHEET

P.

TOTAL

Soil and Rock Strength Parameter Determination

Layer	Undrained Shear Strength (Su) (psf)						Moist Unit Wt. (pcf)		Total Unit Wt. (pcf)		Adopted Short Term Parameters	Long-Term Strength Values						Adopted Long Term Strength Parameters	Consolidation Values								Adopted Consolidation Parameters
	PPR	N-values				Tested						N ₆₀ Value							ODOT GDM Correlations		Tested		Correlated Values			Laboratory Tested Values	
		GDM	Sowers	T and P	Values		Correlation	Tested	Correlation	Tested		Cohesion (psf)	phi (deg)	Cohesion (psf)	phi (deg)	e _o	C _c		C _r = 0.2C _c	e _o	C _c	C _r	P _c				
Layer 1 MEDIUM STIFF COHESIVE	Max	500	875	1225	931		108		118		S _u = 750 psf Φ = 0 deg Y _{moist} = 110 pcf Y _{total} = 120 pcf	Max	7	14	88	22		c' = 90 psf Φ' = 22 deg Y _{moist} = 110 pcf Y _{total} = 120 pcf	Max	0.888	0.243	0.049	N/A	N/A	N/A	N/A	e _o = 0.888 C _c = 0.243 C _r = 0.049 P _c = 5500 psf
	Min	500	875	1225	931		108		118			Min	7	14	88	22			Min	0.888	0.243	0.049	N/A	N/A	N/A	N/A	
	Average	500	875	1225	931		108		118			Average	7	14	88	22			Average	0.888	0.243	0.049	N/A	N/A	N/A	N/A	
	Std Dev	N/A	N/A	N/A	N/A		N/A		N/A			Std Dev	N/A	N/A	N/A	N/A			Std Dev	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	Avg + Std	N/A	N/A	N/A	N/A		N/A		N/A			Avg + Std	N/A	N/A	N/A	N/A			Avg + Std	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	Avg - Std	N/A	N/A	N/A	N/A		N/A		N/A			Avg - Std	N/A	N/A	N/A	N/A			Avg - Std	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Layer 2 VERY STIFF COHESIVE	Max	4500	3875	4000	4000	2538	118	132	128		S _u = 2400 psf Φ = 0 deg Y _{moist} = 130 pcf Y _{total} = 140 pcf	Max	31	48	303	26		c' = 250 psf Φ' = 25 deg Y _{moist} = 130 pcf Y _{total} = 140 pcf	Max	0.772	0.414	0.083	0.628	0.122	0.022	6000	e _o = 0.580 C _c = 0.113 C _r = 0.022 P _c = 5500 psf
	Min	2500	1875	3750	1995	2228	112	129	122			Min	15	22	188	24			Min	0.570	0.198	0.040	0.531	0.104	0.021	5000	
	Average	4154	2900	3975	3073	2383	115	130	125			Average	23	35	250	25			Average	0.665	0.338	0.068	0.580	0.113	0.022	5500	
	Std Dev	658	775	79	808	220	3	2	3			Std Dev	6	8	44	1			Std Dev	0.069	0.068	0.014	0.069	0.013	0.001	707	
	Avg + Std	4812	3675	4054	3881	2602	118	132	128			Avg + Std	29	43	293	26			Avg + Std	0.734	0.405	0.081	0.648	0.126	0.022	6207	
	Avg - Std	3496	2125	3896	2266	2163	112	129	122			Avg - Std	17	26	206	24			Avg - Std	0.596	0.270	0.054	0.511	0.100	0.021	4793	
Layer 3 HARD COHESIVE	Max	4500	10754	4000	4000		130		140		S _u = 4000 psf Φ = 0 deg Y _{moist} = 130 pcf Y _{total} = 140 pcf	Max	93	105	609	28		c' = 440 psf Φ' = 28 deg Y _{moist} = 130 pcf Y _{total} = 140 pcf	Max	0.699	0.261	0.052	N/A	N/A	N/A	N/A	e _o = 0.580 C _c = 0.113 C _r = 0.022 P _c = 5500 psf
	Min	3000	4875	4000	4000		120		130			Min	39	40	353	28			Min	0.400	0.207	0.041	N/A	N/A	N/A	N/A	
	Average	3800	6837	4000	4000		128		138			Average	58	67	441	28			Average	0.489	0.227	0.045	N/A	N/A	N/A	N/A	
	Std Dev	570	2270	0	0		4		4			Std Dev	21	24	98	0			Std Dev	0.109	0.026	0.005	N/A	N/A	N/A	N/A	
	Avg + Std	4370	9107	4000	4000		132		142			Avg + Std	79	91	539	28			Avg + Std	0.598	0.253	0.051	N/A	N/A	N/A	N/A	
	Avg - Std	3230	4566	4000	4000		123		133			Avg - Std	37	43	343	28			Avg - Std	0.381	0.201	0.040	N/A	N/A	N/A	N/A	
Layer 4 DENSE GRANULAR	Max	N/A	N/A	N/A	N/A		122		132		S _u = 0 psf Φ = 37 deg Y _{moist} = 120 pcf Y _{total} = 130 pcf	Max	48	57	N/A	43		c' = 0 psf Φ' = 37 deg Y _{moist} = 120 pcf Y _{total} = 130 pcf	Max	0.400	N/A	N/A	N/A	N/A	N/A	N/A	e _o = N/A C _c = N/A C _r = N/A P _c = N/A psf
	Min	N/A	N/A	N/A	N/A		122		132			Min	48	57	N/A	43			Min	0.400	N/A	N/A	N/A	N/A	N/A	N/A	
	Average	N/A	N/A	N/A	N/A		122		132			Average	48	57	N/A	43			Average	0.400	N/A	N/A	N/A	N/A	N/A	N/A	
	Std Dev	N/A	N/A	N/A	N/A		N/A		N/A			Std Dev	N/A	N/A	N/A	N/A			Std Dev	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	Avg + Std	N/A	N/A	N/A	N/A		N/A		N/A			Avg + Std	N/A	N/A	N/A	N/A			Avg + Std	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	Avg - Std	N/A	N/A	N/A	N/A		N/A		N/A			Avg - Std	N/A	N/A	N/A	N/A			Avg - Std	N/A	N/A	N/A	N/A	N/A	N/A	N/A	

Note: Layer 4 capped at 37 degrees, as the sampler did not encounter refusal conditions.

Values for Soil Strength Correlation	
Reference	Value
HI PI (Sowers)	0.25
MD PI (Sowers)	0.175
LO PI (Sowers)	0.075
T&P	0.133

Liner 2		Groundwater				Short-Term Cohesion (psf)										LT Cohesion (psf)		Midpoint Sample		Dry Unit Wt. (pcf)	Moist Unit Wt. (pcf)	Total Unit Wt. (pcf)	Correlated	Assumed Specific	Computed Void	Dry Unit Wt.	Moist Unit Wt.	Total Unit Wt.	Qu/UU Su	Qu/UU Correlated Eff. c	Laboratory Tested Values						
	N ₆₀	Depth (ft)	Effective Stress (ksf)	N ₆₀	% Rec	HP	% Gr	% CS	% FS	% Silt	% Clay	LL	PL	PI	% Water	PPR	GDM	Sowers	T & P	phi (deg)	Depth (ft.)	Flowline (ft.)	per GDM	C _u	Ratio (e)	(pcf)	(pcf)	(pcf)	(psf)	(psf)	e _s	C _c	C _i	F _c	P _r	(psf)	
Max	13	1.362	48	100	4.5	16	6	15	48	52	56	23	34	21	4500	3875	4000	4000	303	26	11.5	-0.8	105	0.414	2.70	0.772	128	132	N/A	2538	231	1	0	0	6000		
Min	15	1.11	44	94	2.1	12	2	2500	42	32	2	2500	42	12	Average	1875	1965	1965	54	25	0.8	11.5	102	0.414	2.70	0.772	128	132	N/A	2538	231	1	0	0	6000		
Average	23	1.3	63.32	35	80	4.2	4	1	10	38	44	28	21	27	16	Average	2900	3975	3073	250	25	5.4	-3.2	100	0.338	2.65	0.665	111	130	N/A	2283	222	1	0	0	5500	
Std Dev	6	2	0.084	8	17	0.7	5	1	3	7	4	2	6	3	Std Dev	658	775	79	808	44	1	3.2	-4.4	4	0.068	0.01	0.069	2	2	N/A	2380	13	0	0	7507		
Avg + Std	29	15	1.018	43	97	4.8	9	5	14	44	48	55	23	33	19	Avg + Std	4812	3675	4054	3881	293	26	8.6	-2.1	104	0.405	2.67	0.734	112	132	N/A	2602	235	1	0	0	6207
Avg - Std	17	10	0.246	26	63	3.5	-1	3	7	31	40	40	18	21	14	Avg - Std	3496	2125	3896	2266	206	24	2.1	-8.6	96	0.270	2.64	0.596	109	129	N/A	2163	209	1	0	0	4793

[illegible]

Values for Soil Strength Correlation	
Reference	Value
HI PI (Sowers)	0.25
MD PI (Sowers)	0.175
LO PI (Sowers)	0.075
T&P	0.133

Layer 4															Short-Term Cohesion (psf)				LT Cohesion	phi	Midpoint Sample	Midpoint Sample	Dry Unit Wt.	Moist Unit Wt.	Total Unit Wt.	Correlated	Assumed Specific	Computed
	N ₆₀	Groundwater Depth (ft)	Effective Stress (ksf)	N ₁₆₀	% Rec	HP	% Gr	% CS	% FS	% Fines	LL	PL	PI	% WC		N-values			per GDM	(deg)	Depth (ft.)	Elevation (ft.)	(pcf)	(pcf)	(pcf)	C _c	Gravity (G _s)	Void Ratio (e)
															PPR	GDM	Sowers	T & P										
Max	48	11	1.142	57	17	N/A	88	7	3	2	N/A	N/A	N/A	1		N/A	N/A	N/A	N/A	43	9.8	-9.8	121	122	132	N/A	2.71	0.400
Min	48	11	1.142	57	17	N/A	88	7	3	2	N/A	N/A	N/A	1		N/A	N/A	N/A	N/A	43	9.8	-9.8	121	122	132	N/A	2.71	0.400
Average	48	11	1.142	57	17	N/A	88	7	3	2	N/A	N/A	N/A	1		N/A	N/A	N/A	N/A	43	9.8	-9.8	121	122	132	N/A	2.71	0.400
Std Dev	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Avg + Std	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Avg - Std	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Alignment	Surface Elevation	Exploration ID	From	To	Sample ID	N ₆₀	Groundwater Depth (ft)	Effective Stress (ksf)	N ₁₆₀	% Rec	HP	% Gr	% CS	% FS	% Fines	LL	PL	PI	% WC	ODOT Class.	Soil Type	Layer	PPR	Short-Term Cohesion (psf)			LT Cohesion (psf)	phi (deg)	Midpoint Sample Depth (ft.)	Midpoint Sample Elevation (ft.)	Dry Unit Wt. (pcf)	Moist Unit Wt. (pcf)	Total Unit Wt. (pcf)	Correlated C _c	Assumed Specific Gravity (G _s)	Computed Void Ratio (e)
																								N-values												
																								GDM	Sowers	T & P										
		B-002-0-24	9	-	10.5	SS-5	48	10.5	1.142	57	17	-	88	7	3	2	NP	NP	NP	1	A-1-a	Granular	4	N/A			43	9.8	-9.8	121	122	132	N/A	2.71	0.400	

PROJECT: HAM-126-19.50			DRILLING FIRM / OPERATOR: NEAS / J. HODGES					DRILL RIG: CME 55 TRACK			STATION / OFFSET: 263+17, 88' RT.					EXPLORATION ID B-001-0-24						
TYPE: BRIDGE			SAMPLING FIRM / LOGGER: HDR / D. MATCHISON					HAMMER: CME AUTOMATIC			ALIGNMENT: SR 126											
PID: 114652 SFN: 3118991			DRILLING METHOD: 3.25" HSA / NQ2					CALIBRATION DATE: 3/8/24			ELEVATION: 825.0 (MSL) EOB: 30.0 ft.					EI 795						
START: 9/25/24 END: 9/25/24			SAMPLING METHOD: SPT / ST / NQ2					ENERGY RATIO (%): 79.9			LAT / LONG: 39.226022, -84.370410											
MATERIAL DESCRIPTION AND NOTES				ELEV.	DEPTHS		SPT/RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	HOLE SEALED
				825.0																		
VERY STIFF, BROWN MOTTLED GRAY, CLAY , "AND" SILT, LITTLE SAND, TRACE GRAVEL, DAMP @0.0' - 0.5': root hairs Layer 2				820.0	1		2 5 6	15	67	SS-1	3.00	-	-	-	-	-	-	-	18	A-7-6 (V)		
					2																	
					3		4 6 8	19	67	SS-2	4.00	1	3	8	44	44	47	23	24	17		A-7-6 (15)
					4																	
VERY STIFF, BROWN TO ORANGE-BROWN MOTTLED GRAY, CLAY , SOME SILT, LITTLE SAND, TRACE GRAVEL, NOTED BLACK IRON CONCRETIONS, DAMP @7.1' - 7.6': qu = 4,455 psf @9.0' - 9.5': auger grinding and chatter (limestone fragments)				815.0	5		3 4 8	16	67	SS-3	4.00	2	5	15	33	45	55	21	34	20	A-7-6 (19)	
					6																	
					7				92	ST-4	2.50	3	4	15	35	43	42	20	22	17	A-7-6 (13)	
					8																	
VERY STIFF TO HARD, BROWN MOTTLED GRAY, SILTY CLAY , LITTLE GRAVEL, LITTLE SAND, DAMP Layer 3				807.5	9																	
					10		9 16 24	53	89	SS-5	4.00	-	-	-	-	-	-	-	12		A-6b (V)	
					11																	
					12																	
@16.5': brown shale at bottom of SS-7				805.0	13		11 19 23	56	67	SS-6	4.00	12	7	12	36	33	33	17	16	11	A-6b (9)	
					14																	
					15		5 9 20	39	89	SS-7	3.50	-	-	-	-	-	-	-	21	A-6b (V)		
					16																	
SHALE/LIMESTONE, GRAY, SEVERELY WEATHERED, VERY WEAK.				805.0	17																	
					18		48 50/4"	-	90	SS-8	-	-	-	-	-	-	-	-	9		Rock (V)	
INTERBEDDED SHALE (71%) AND LIMESTONE (29%), JOINT AND BEDDING DISCONTINUITIES, FRACTURED TO HIGHLY FRACTURED, NARROW TO OPEN APERTURE WIDTH, SLICKENSIDED SURFACE, LAMINATED/SHEARED STRUCTURE, POOR SURFACE, RQD 7%, REC. 97%; SHALE, GRAY, MODERATELY TO HIGHLY WEATHERED, VERY WEAK, LAMINATED TO THIN BEDDED, ARGILLACEOUS; LIMESTONE, GRAY, MODERATELY TO HIGHLY WEATHERED, STRONG, VERY THIN TO THIN BEDDED. @20' - 20.8', 22.2' - 22.5', 24.2' - 24.5': Sc = 454 psi (combined point load test)				795.0	19		50/5"	-	60	SS-9	-	-	-	-	-	-	-	-	8	Rock (V)		
					20																	
					21		13		100	NQ2-1												CORE
					22																	
					23																	
					24																	
					25		7		100	NQ2-2												
				EOB	26																	
					27																	
					28																	
					29		0		87	NQ2-3												CORE
NOTES: NONE																						
ABANDONMENT METHODS, MATERIALS, QUANTITIES: TREMIED 30 LB. BENTONITE GROUT: 30 GAL. WATER																						

PROJECT: HAM-126-19.50	DRILLING FIRM / OPERATOR: NEAS / J. HODGES	DRILL RIG: CME 55 TRACK	STATION / OFFSET: 264+14, 58' RT.	EXPLORATION ID: R-002-0-24
TYPE: BRIDGE	SAMPLING FIRM / LOGGER: HDR / A. BARATTA	HAMMER: CME AUTOMATIC	ALIGNMENT: SR 126	EI 796.2
PID: 114652 SFN: 3118991	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 3/8/24	ELEVATION: 818.0 (MSL) EOB: 21.8 ft.	
START: 9/24/24 END: 9/24/24	SAMPLING METHOD: SPT / NQ2	ENERGY RATIO (%): 79.9	LAT / LONG: 39.226078, -84.370100	

[illegible]

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 6/4/25 12:36 - C:\PWWORKING\EAST01\D3184708\HAM-126-19.50.GPJ

NOTES: BORING PERFORMED IN DITCH CONTAINING HYDROPHILIC VEGETATION. RAIN OCCURRED OVERNIGHT, PRIOR TO DRILLING.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: TREMIED 40 LB. BENTONITE GROUT: 55 GAL. WATER

Included with Layer 3 for parameter development,
omitted from profile as a separate layer.

PROJECT: HAM-126-19.50		DRILLING FIRM / OPERATOR: NEAS / J. HODGES		DRILL RIG: CME 55 TRACK		STATION / OFFSET: 264+17, 65' LT.		EXPLORATION ID													
TYPE: BRIDGE		SAMPLING FIRM / LOGGER: HDR / A. BARATTA		HAMMER: CME AUTOMATIC		ALIGNMENT: SR 126		B-003-0-24													
PID: 114652 SFN: 3118991		DRILLING METHOD: 3.25" HSA / NQ2		CALIBRATION DATE: 3/8/24		ELEVATION: 822.0 (MSL) EOB: 24.5 ft.		PAGE													
START: 9/26/24 END: 9/26/24		SAMPLING METHOD: SPT / ST / NQ2		ENERGY RATIO (%): 79.9		LAT / LONG: 39.226401, -84.369991		1 OF 1													
MATERIAL DESCRIPTION AND NOTES			ELEV.	DEPTHS		SPT/ROD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	HOLE SEALED
			822.0								GR	CS	FS	SI	CL	LL	PL	PI			
TOPSOIL (1")			821.9	1																	
VERY STIFF TO HARD, BROWN TRACE GRAY, CLAY, SOME SILT, LITTLE SAND, TRACE STONE FRAGMENTS, DAMP				2																	
@2.5' - 3.0': qu = 5,076 psf			818.5	3				83	ST-1	4.5+	2	6	14	29	49	54	23	31	21	A-7-6 (19)	
VERY STIFF TO HARD, BROWN TRACE GRAY, SILTY CLAY, SOME STONE FRAGMENTS, LITTLE SAND, DAMP				4		7	19	48	89	SS-2	3.00	23	8	11	30	28	33	17	16	12	A-6b (7)
@6.0': no recovery				5			17														
Layer 2				6		11															
				7		10	32	0	SS-3	-	-	-	-	-	-	-	-	-	-		
			813.5	8																	
VERY STIFF, BROWN TRACE ORANGE, SILTY CLAY, LITTLE SAND, TRACE STONE FRAGMENTS, DAMP				9		4	8	27	100	SS-4	4.5+	2	3	12	43	40	32	16	16	14	A-6b (10)
			811.0	10																	
VERY STIFF, BROWN TRACE ORANGE, CLAY, SOME SILT, LITTLE SAND, TRACE STONE FRAGMENTS, DAMP			810.1	11					100	ST-5	4.50	9	4	9	35	43	41	20	21	16	A-7-6 (13)
SHALE/LIMESTONE, GRAY, SEVERELY WEATHERED, VERY WEAK.			808.5	12		21			67	SS-6	-	-	-	-	-	-	-	-	-	11	Rock (V)
SHALE, GRAY, SEVERELY WEATHERED, VERY WEAK.			807.5	13																	
				14		25			82	SS-7	-	-	-	-	-	-	-	-	-	11	Rock (V)
INTERBEDDED SHALE (69%) AND LIMESTONE (31%), JOINT AND BEDDING DISCONTINUITIES, FRACTURED TO HIGHLY FRACTURED, NARROW TO OPEN APERTURE WIDTH, SLICKENSIDED TO SLIGHTLY ROUGH SURFACE, BLOCKY/DISTURBED/SEAMY STRUCTURE, POOR TO FAIR SURFACE, RQD 37%, REC. 93%;				15																	
SHALE, GRAY, MODERATELY TO HIGHLY WEATHERED, VERY WEAK, VERY THIN TO THIN BEDDED, ARGILLACEOUS, CALCAREOUS;				16																	
LIMESTONE, GRAY, MODERATELY WEATHERED, VERY STRONG, VERY THIN TO THIN BEDDED.				17																	
				18		33		94	NQ2-1												CORE
				19																	
				20																	
				21																	
				22																	
				23		45		91	NQ2-2												CORE
			797.5	24																	
				EOB																	
NOTES: NONE																					
ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 25 LB. BENTONITE CHIPS; TREMIED 25 LB. BENTONITE GROUT; 25 GAL. WATER																					

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT GDT - 6/4/25 12:36 - C:\P\WORKING\GEAST01\03184708\HAM-126-19.50.GPJ

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT GDT - 6/4/25 12:36 - C:\PWWORKING\GEAST01\03184708\HAM-126-19.50.GPJ

PROJECT: HAM-126-19.50		DRILLING FIRM / OPERATOR: NEAS / J. HODGES		DRILL RIG: CME 55 TRACK		STATION / OFFSET: 262+83, 82' LT.		EXPLORATION ID											
TYPE: BRIDGE		SAMPLING FIRM / LOGGER: HDR / A. BARATTA		HAMMER: CME AUTOMATIC		ALIGNMENT: SR 126		B-004-0-24											
PID: 114652 SFN: 3118991		DRILLING METHOD: 3.25" HSA / NQ2		CALIBRATION DATE: 3/8/24		ELEVATION: 823.0 (MSL) EOB: 23.3 ft.		EI 799.7											
START: 9/26/24 END: 9/26/24		SAMPLING METHOD: SPT / ST / NQ2		ENERGY RATIO (%): 79.9		LAT / LONG: 39.226497, -84.370498													
MATERIAL DESCRIPTION AND NOTES		ELEV.	DEPTHS	SPT/RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	HOLE SEALED
		823.0							GR	CS	FS	SI	CL	LL	PL	PI			
TOPSOIL (1")		822.9	1	3															
VERY STIFF TO HARD, BROWN TRACE GRAY, CLAY , "AND" SILT, TRACE STONE FRAGMENTS, TRACE SAND, TRACE ROOTS, DAMP			2	4	17	89	SS-1	4.5+	1	3	7	48	41	51	22	29	16	A-7-6 (18)	
Layer 2			3	7															
			4	10	29	44	SS-2	-	-	-	-	-	-	-	-	-	16	A-7-6 (V)	
		818.0	5																
VERY STIFF TO HARD, BROWN AND GRAY, CLAY , SOME TO "AND" SILT, TRACE TO LITTLE SAND, TRACE STONE FRAGMENTS, DAMP			6	5	29	89	SS-3	4.5+	1	3	10	34	52	51	19	32	15	A-7-6 (18)	
			7	9															
		814.9	8	6	-	50	ST-4A ST-4B	4.5+ -	3 58	2 7	7 4	44 12	44 19	56 38	22 20	34 18	18 7	A-7-6 (19) A-2-6 (1)	
@7'-8'-11': seam of stone fragments with sand, silt, and clay			9	50/6"			SS-5	4.5+	33	10	7	16	34	39	20	19	11	A-6b (6)	
HARD, BROWN TO BROWNISH-GRAY, SILTY CLAY , SOME STONE FRAGMENTS, LITTLE SAND, DAMP			10	10	93	78	SS-6A	-	-	-	-	-	-	-	-	-	8	A-6b (V)	
Layer 3			11	38			SS-6B	-	35	8	3	25	29	36	19	17	8	A-6b (7)	
HARD, GRAY, SILTY CLAY , SOME STONE FRAGMENTS, LITTLE SAND, DAMP		812.0	12	32															
		810.5	13	12	-	56	SS-7	-	-	-	-	-	-	-	-	-	6	Rock (V)	
SHALE/LIMESTONE, GRAY, SEVERELY WEATHERED, VERY WEAK.		809.7	14	50/3"															
INTERBEDDED SHALE (69%) AND LIMESTONE (31%), JOINT AND BEDDING DISCONTINUITIES, FRACTURED TO HIGHLY FRACTURED, NARROW TO OPEN APERTURE WIDTH, SLICKENSIDED TO SLIGHTLY ROUGH SURFACE, LAMINATED/SHEARED STRUCTURE, VERY POOR TO POOR SURFACE, RQD 17%, REC. 90%;			15																
SHALE, GRAY, MODERATELY TO HIGHLY WEATHERED, VERY WEAK, VERY THIN TO THIN BEDDED, ARGILLACEOUS, CALCAREOUS;			16	23		82	NQ2-1											CORE	
LIMESTONE, GRAY, MODERATELY WEATHERED, VERY STRONG, VERY THIN TO THIN BEDDED.			17																
			18																
			19																
			20																
			21	9		100	NQ2-2											CORE	
			22																
			23																
		799.7	24																
			25																
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Unconfined Compressive Strength of Cohesive Soil (ASTM D2166)

(Project: HAM-126-19.50, Boring Location: B-001-0-24, ST-4, Depth: 7.1-7.6 ft)

Tested Date: 11/4/2024

Specimen Properties

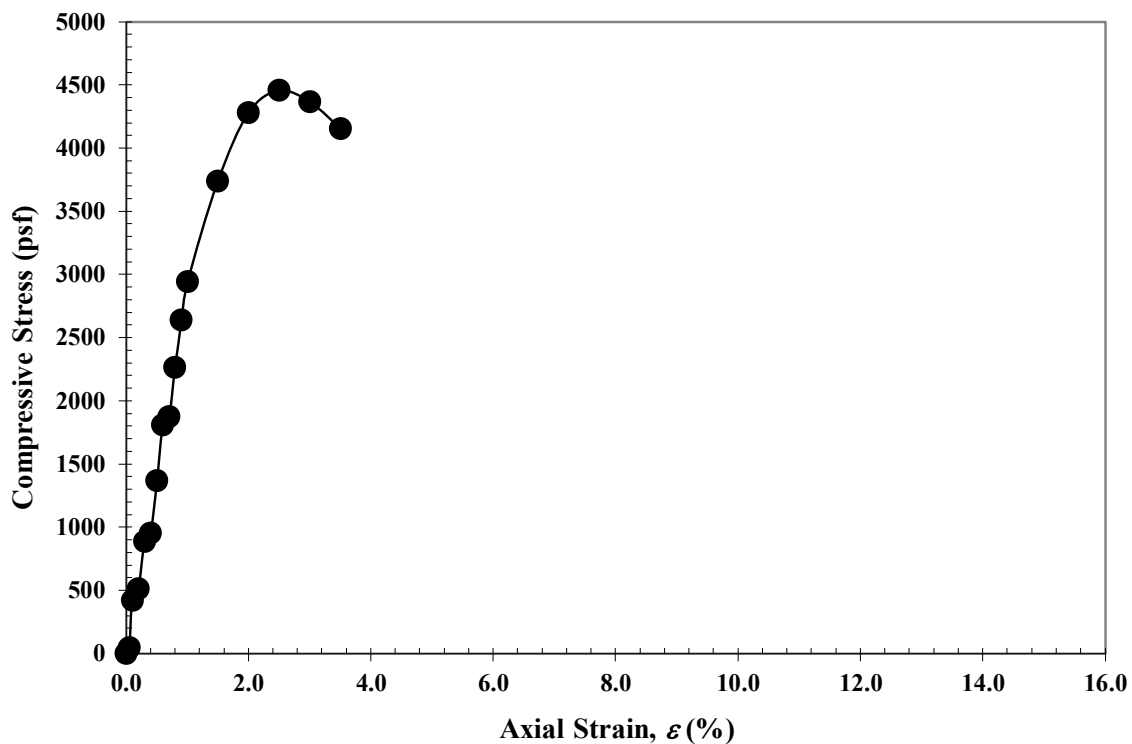
Average Dia., D_{avg} (in):	2.88
Average Height, H_{avg} (in):	5.75
Area, A (in ²):	6.49
Volume, V (in ³):	37.36
Wet Mass of Specimen (lb):	2.8
Moisture Content (%):	18.0
Dry Mass of Specimen (lb):	2.4
Wet Unit Weight, γ (lb/ft ³):	129.2
Dry Unit Weight, γ_d (lb/ft ³):	109.5

Final Specimen Figure



Results

Unconfined Compressive Strength (psf):	4455
Strain (%):	2.5



Notes: Very stiff, brown mottled with gray and orangish brown, CLAY, some silt, little sand, trace gravel, damp.

Unconfined Compressive Strength of Cohesive Soil (ASTM D2166)

(Project: HAM-126-19.50, Boring Location: B-003-0-24, ST-1, Depth: 2.5-3.0 ft)

Tested Date: 11/4/2024

Specimen Properties

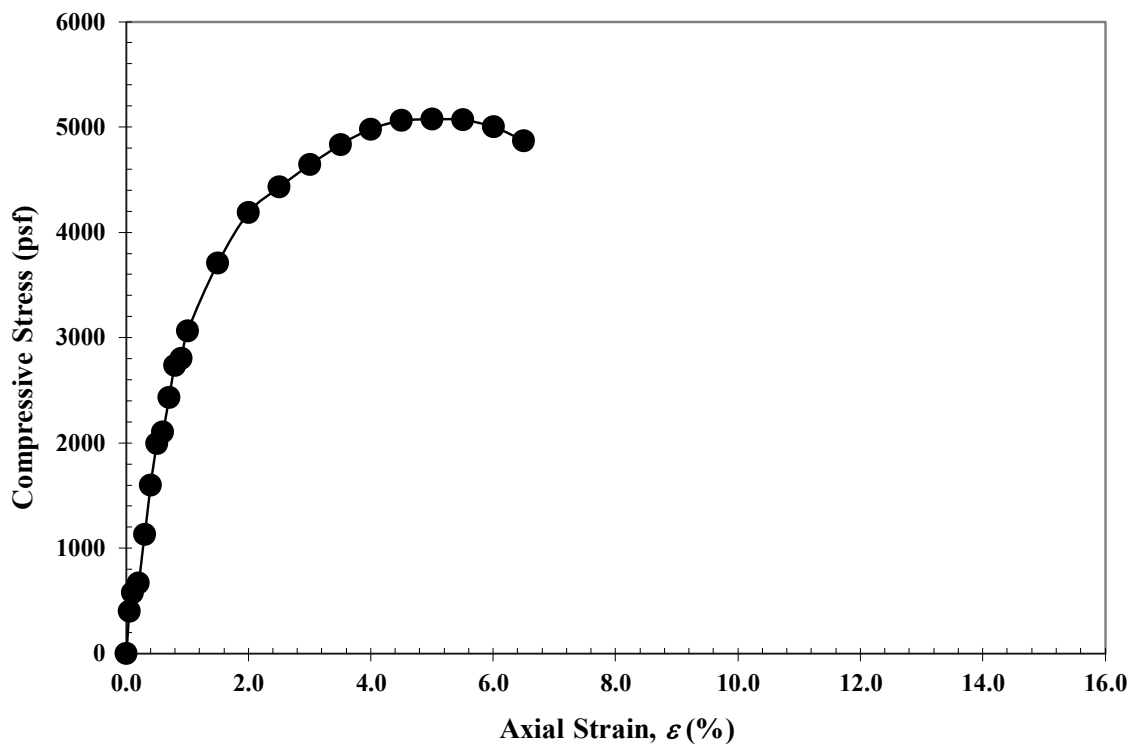
Average Dia., D_{avg} (in):	2.87
Average Height, H_{avg} (in):	5.74
Area, A (in ²):	6.47
Volume, V (in ³):	37.14
Wet Mass of Specimen (lb):	2.8
Moisture Content (%):	17.9
Dry Mass of Specimen (lb):	2.4
Wet Unit Weight, γ (lb/ft ³):	131.7
Dry Unit Weight, γ_d (lb/ft ³):	111.7

Final Specimen Figure



Results

Unconfined Compressive Strength (psf):	5076
Strain (%):	5.0



Notes: Very stiff, brown and gray, CLAY, some silt, little sand, trace gravel, damp.

Consolidation Test

Project Name: HAM-126-19.50

Source: B-001-0-24 ST-4 (7.7'-7.8')

Description: Very stiff, brown mottled with orangish brown and gray, CLAY,
some silt, little sand, trace gravel, damp.

Prepared by: LR

Checked by: ZM

Date: 11/18/2024

Test Specification: ASTM D 2435

Initial Void Ratio: 0.531

Initial Bulk Unit Weight (lb/ft³): 130

In-situ Vertical Effective Stress (psf): 924

Dry Unit Weight (lb/ft³): 110

Compression and Swelling Index

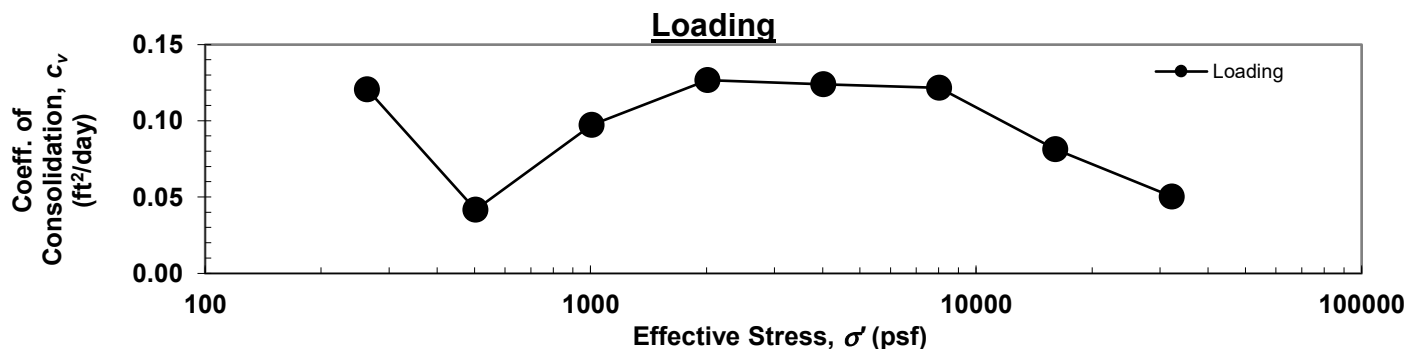
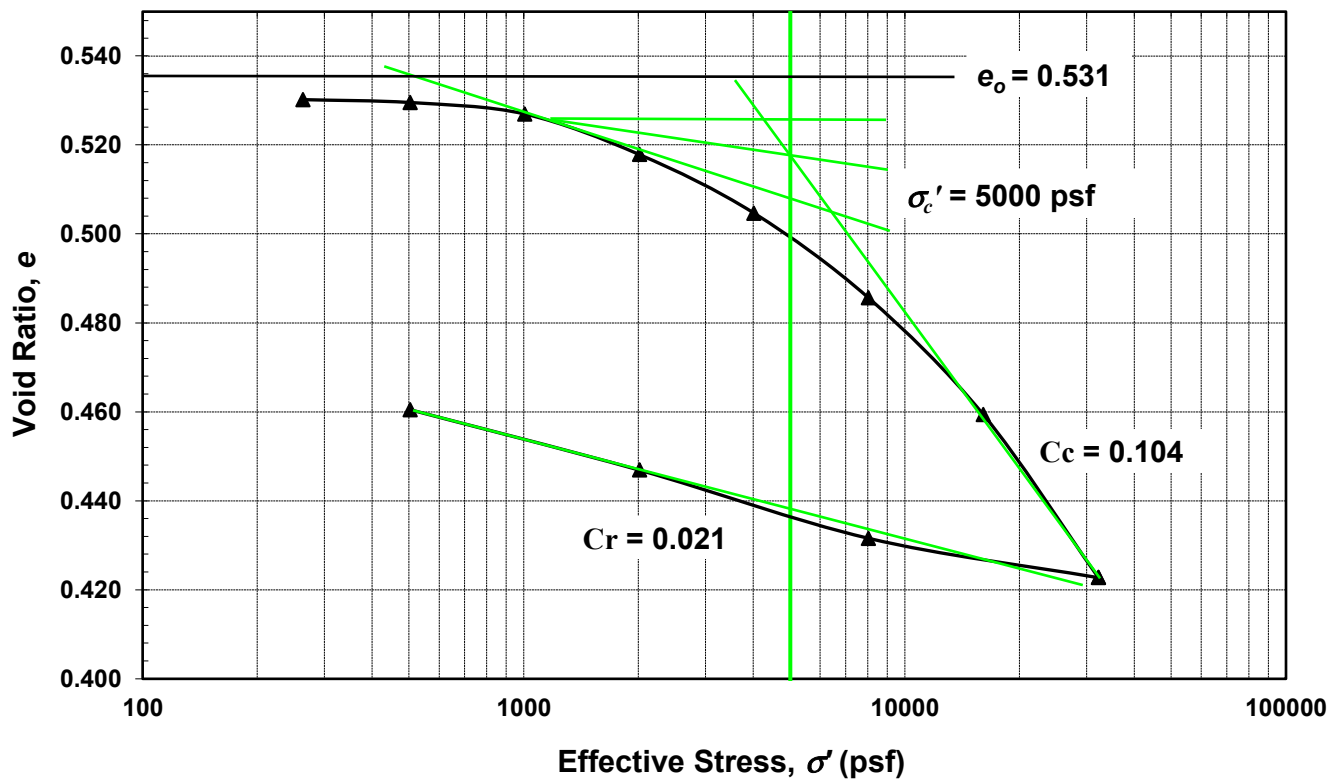
Compression Index (C_c): 0.104

Preconsolidation Pressure (σ'_c)(psf): 5000

Recompression Index (C_r): 0.021

Over-Consolidation Ratio (OCR): 5.4

Consolidation Curve



Consolidation Test

Project Name: HAM-126-19.50

Source: B-003-0-24 ST-1 (2.2'-2.3')

Description: Hard, brown and gray, CLAY, some silt, little sand, trace gravel, damp.

Prepared by: LR

Checked by: ZM

Date: 11/18/2024

Test Specification: ASTM D 2435

Initial Void Ratio: 0.628

Initial Bulk Unit Weight (lb/ft³): 127

In-situ Vertical Effective Stress(psf): 264

Dry Unit Weight (lb/ft³): 104

Compression and Swelling Index

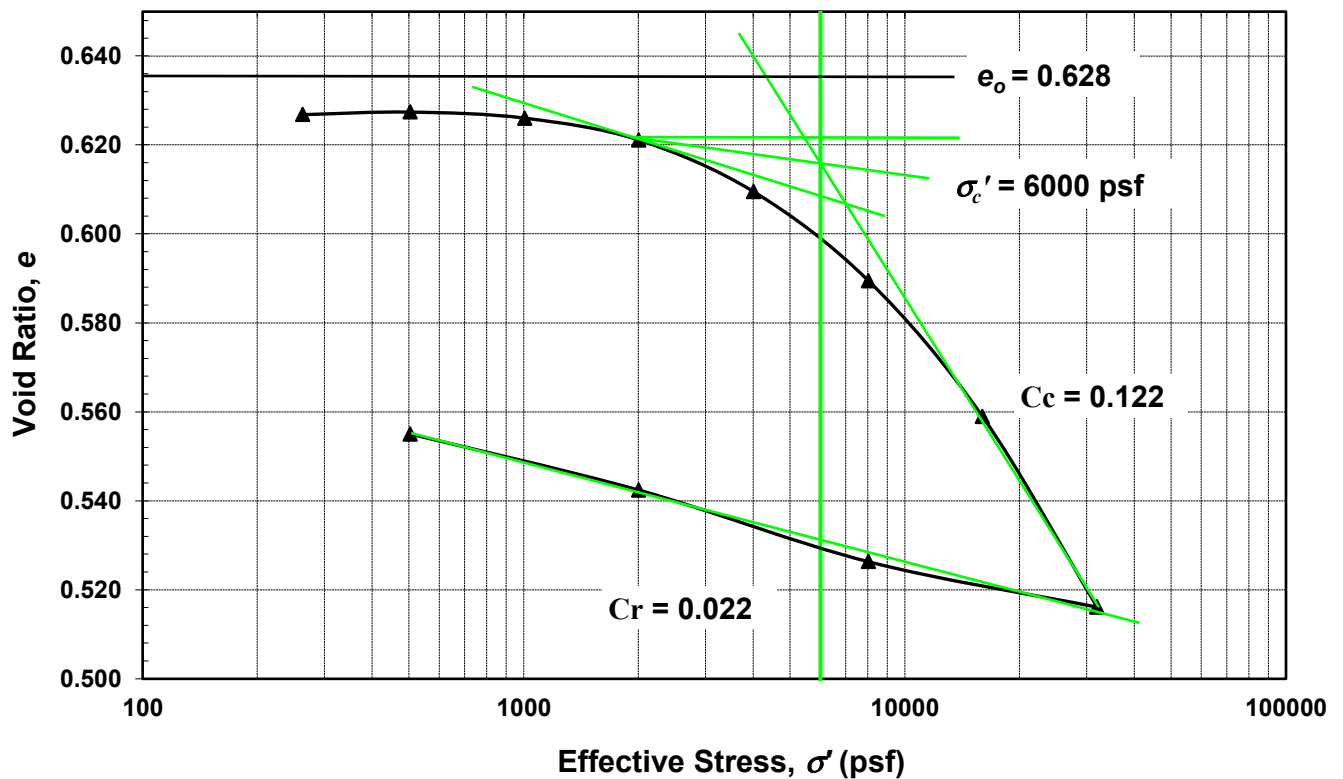
Compression Index (C_c): 0.122

Preconsolidation Pressure (σ'_c)(psf): 6000

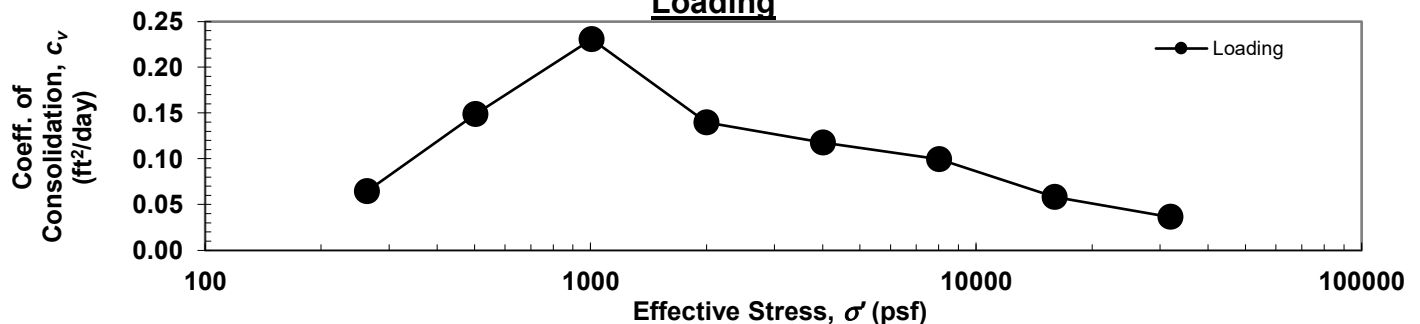
Recompression Index (C_r): 0.022

Over-Consolidation Ratio (OCR): 22.7

Consolidation Curve



Loading



WEATHERED BEDROCK WITH SPT

Hammer Efficiency 79.9 %

Project	Exploration ID	Sample Depth (ft)	Sample ID	Rock Type	Color	Moist Unit Weight (pcf)		No. Refusal Blows	Refusal Distance (in)	N79.9	N90	Compressive Strength, Qu		
						GDM Range	USE					(ksf)	(psi)	(MPa)
HAM-126-19.50	B-001-0-24	17.5	SS-8	Shale (Weathered)	Gray	150 - 160	155	50	4	150	133.1667	12	85	0.6
HAM-126-19.50	B-001-0-24	19	SS-9	Shale (Weathered)	Gray	150 - 160	155	50	5	120	106.5333	10	68	0.5
HAM-126-19.50	B-002-0-24	11.5	SS-6	Shale (Weathered)	Gray	150 - 160	155	50	3	200	177.5556	16	113	0.8
HAM-126-19.50	B-003-0-24	11.9	SS-6	Shale (Weathered)	Gray	150 - 160	155	50	3	200	177.5556	16.335	113	0.8
HAM-126-19.50	B-003-0-24	13.5	SS-7	Shale (Weathered)	Gray	150 - 160	155	50	5	120	106.5333	9.8011	68	0.5
HAM-126-19.50	B-004-0-24	12.5	SS-7	Shale (Weathered)	Gray	150 - 160	155	50	3	200	177.5556	16.335	113	0.8
				Shale (Weathered)	Maximum		155			Maximum		16	113	
					Minimum		155			Minimum		10	68	
					Average		155			Average		13	94	
					Std Dev		0			Std Dev		3	23	
					Adopted Value		155			Adopted Value		14	100	

$Q_u \text{ (ksf)} = 0.092 * N_{90}$ (ODOT GDM Section 404.3)

Table 400-5: Rock Properties of Typical Rock Types Found in Ohio (Masada and Han, 2013)

Rock Type	Unit Weight (pcf)	Unconfined Compressive Strength (psi)	Slake Durability Index (%)
Claystone	130-165	15-1400	0-60
Shale	155-165 (unweathered) 150-160 (weathered)	2100-4600 (unweathered) 100-400 (weathered)	20-90
Siltstone	160-170	3600-8100	65-90
Sandstone	155-165	1800-7800	85-100
Friable Sandstone	125-140	<3600	<85
Limestone	155-170	3500-16400	95-100
Dolomite	165-175	4100-10300	95-100
Coal	80-85	1300-7000	NA
Underclay	125-135	200-400	0-20

BEDROCK CORE TESTING

Project	Exploration ID	Sample Depth (ft)	Sample ID	Rock Type	Color	Moist Unit Weight (pcf)	Geologic Strength Descriptor	Compressive Strength, Qu			Er Modulus (MPa)	GSI Range	USE	Em (Hoek & Brown) Modulus (GPa)	Lesser of Er vs Em (psi)	Em (Yang) Modulus (MPa)	
								Based on Rock Type (psi)	(psi)	(MPa)							
HAM-126-19.50	B-001-0-24	20	NQ2-1/NQ2-2	Shale (Weathered)	Gray	N/A	Very Weak	100 - 400	454	3.1			10-20	15	0.2	34219	34219
				Shale (Weathered)	Maximum	0		Shale (Weathered)	454				Shale (Weathered)			34219	34219
					Minimum	0			454							34219	34219
					Average	N/A			454							34219	34219
					Std Dev	N/A			N/A							N/A	N/A
					Adopted Value	155			450							34200	34200

Project	Exploration ID	Sample Depth (ft)	Sample ID	Rock Type	Color	Moist Unit Weight (pcf)	Geologic Strength Descriptor	Compressive Strength, Qu			Er		GSI		Em (Hoek & Brown)		Lesser of Er vs Em		Em (Yang)	
								Based on Rock Type (psi)	(psi)	(MPa)	(psi)	(MPa)	Range	USE	(GPa)	(psi)	(psi)	(psi)	(MPa)	(psi)
HAM-126-19.50	B-002-0-24	14.2	NQ2-2	Limestone	Gray	168.1	Very Strong	3500 - 16400	16183	111.6	2,889,821	19925	15-25	20	1.8	257918	257918	500.7	72627	
				Limestone	Maximum	16183														
					Minimum	16183														
					Average	16183														
					Std Dev	N/A														
					Adopted Value	16150														
					krm	0.0005														

BEDROCK CORE QUALITY

Project	Exploration ID	Rock Type	Depth Range (ft.) From To	Thickness (ft)	Layer RQD (%)	Weighted RQD ¹ (Length / Total Length)
HAM-126-19.50	B-001-0-24	Shale (Weathered)	20 30	10	7	1.8
HAM-126-19.50	B-002-0-24	Shale (Weathered)	11.8 21.8	10	13	3.3
HAM-126-19.50	B-003-0-24	Shale (Weathered)	14.5 24.5	10	37	9.3
HAM-126-19.50	B-004-0-24	Shale (Weathered)	13.3 23.3	10	17	4.3
				Shale (Weathered)	40	RQD SUM
				Maximum	10	
				Minimum	10	
				Average	10.0	18.5
				Adopted Value		20

Table 400-5: Rock Properties of Typical Rock Types Found in Ohio (Masada and Han, 2013)

Rock Type	Unit Weight (pcf)	Unconfined Compressive Strength (psi)	Slake Durability Index (%)
Claystone	130-165	15-1400	0-60
Shale	155-165 (unweathered) 150-160 (weathered)	2100-4600 (unweathered) 100-400 (weathered)	20-90
Siltstone	160-170	3600-8100	65-90
Sandstone	155-165	1800-7800	85-100
Friable Sandstone	125-140	<3600	<85
Limestone	155-170	3500-16400	95-100
Dolomite	165-175	4100-10300	95-100
Coal	80-85	1300-7000	NA
Underclay	125-135	200-400	0-20

Table 400-6: Estimated Bedrock Strength Characteristics from Visual Description

Geologic Strength Descriptor	Q _u (psi)	E _i (psi)	Historic Hardness Descriptor (used prior to 2007)
Very Weak	200	18000	Very Soft
Very Weak to Weak	360	32000	Very Soft to Soft
Weak	750	68000	Soft
Weak to Slightly Strong	1125	100000	Soft to Medium
Slightly Strong	1500	140000	Medium / Medium-Firm
Slightly Strong to Moderately Strong	2250	200000	Medium to Moderately Hard
Moderately Strong	3600	320000	Moderately Hard
Moderately Strong to Strong	5000	450000	Moderately Hard to Hard
Strong	7500	680000	Hard
Strong to Very Strong	10000	900000	Hard to Very Hard
Very Strong	15000	1400000	Very Hard
Very Strong to Extremely Strong	20000	1800000	
Extremely Strong	30000	2700000	

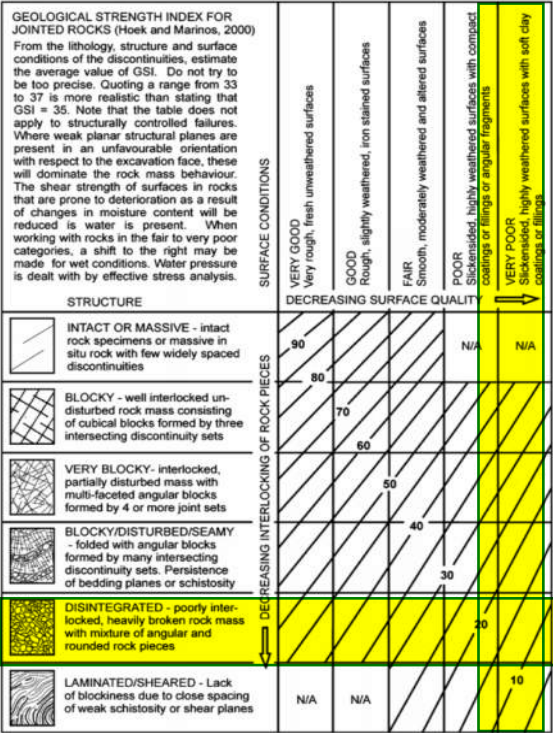


Figure 10.4.6.4-1—Determination of *GSI* for Jointed Rock Mass (Hoek and Marinos, 2000)

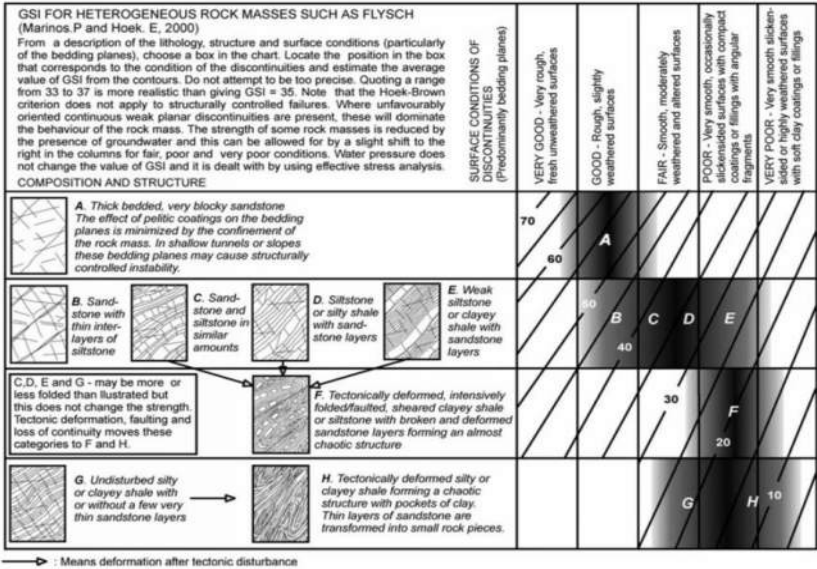


Figure 10.4.6.4-2—Determination of *GSI* for Tectonically Deformed Heterogeneous Rock Masses (Marinos and Hoek 2000)

Table 10.4.6.5-1—Estimation of *E_m* Based on *GSI*

Expression	Notes/Remarks	Reference
$E_m (GPa) = \sqrt[4]{\frac{GSI-10}{q_u-10} \cdot 40}$ for $q_u \leq 100$ MPa	Accounts for rocks with $q_u < 100$ MPa; notes q_u in MPa	Hoek and Brown (1997); Hoek et al. (2002)
$E_m (GPa) = 10^{\frac{GSI-10}{40}}$ for $q_u \leq 100$ MPa		
$E_m = \frac{E_R}{100} e^{\frac{GSI}{21.7}}$	Reduction factor on intact modulus, based on <i>GSI</i>	Yang (2006)
Notes: <i>E_r</i> = modulus of intact rock, <i>E_m</i> = equivalent rock mass modulus, <i>GSI</i> = geological strength index, <i>q_u</i> = uniaxial compressive strength, and 1 MPa = 2.09 ksf.		

Unconfined Compressive Strength of Rock Core (ASTM D7012 Method C)

(Project: HAM-126-19.50, Boring Location: B-002-0-24, NQ2-2, Depth: 14.2-14.5ft)

Tested Date: 11/7/2024

Specimen Properties

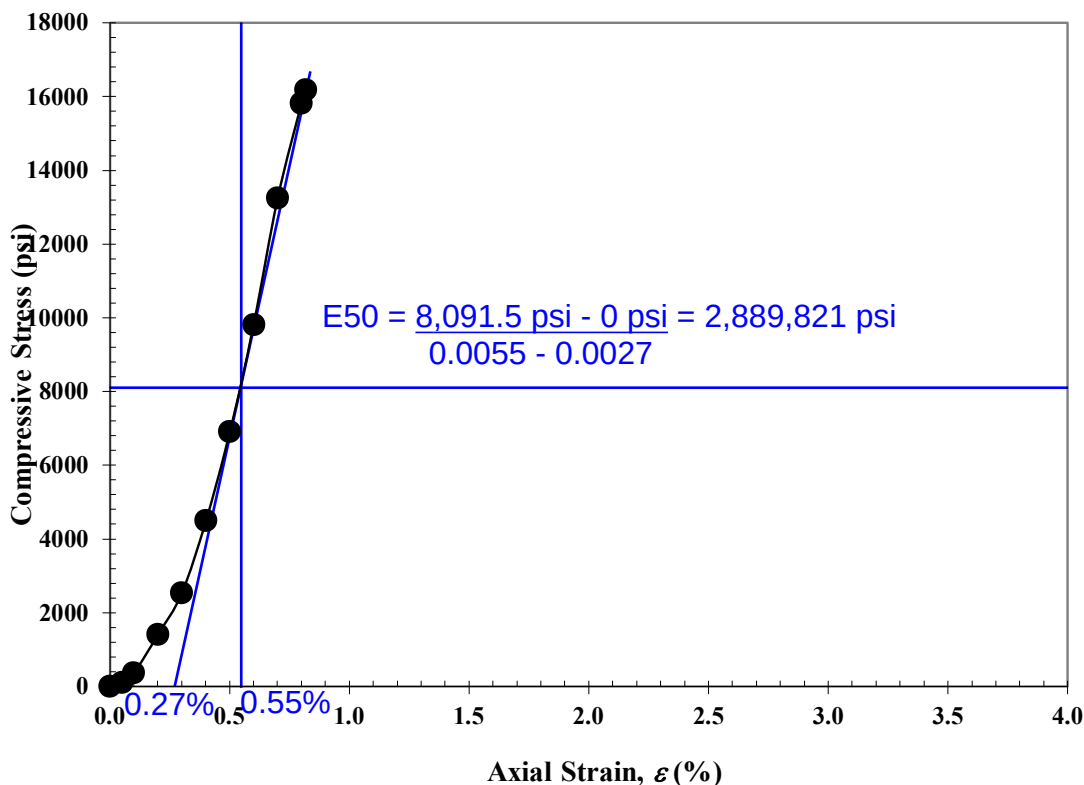
Average Dia., D_{avg} (in):	1.98
Average Height H_{avg} (in):	3.79
Length to Diameter Ratio:	1.92
Area, A (in ²):	3.07
Volume, V (in ³):	11.65
Wet Mass of Specimen (lb):	1.1
Moisture Content (%):	0.2
Dry Mass of Specimen (lb):	1.1
Wet Unit Weight, γ (lb/ft ³):	168.1
Dry Unit Weight, γ_d (lb/ft ³):	167.8

Final Specimen Figure



Results

Unconfined Compressive Strength (psi):	16183	112	(MPa)
Strain (%):	0.8		



Notes: Limestone, gray, slightly weathered, very strong. Please note that this specimen does not meet the L/D ratio of D7012 and the results reported may differ from a specimen that does meet the L/D requirements of D7012.

between adjacent facing panel columns. Otherwise, use only one soil reinforcement system for the entire length of the retaining wall

2. Unless a longer minimum soil reinforcement length is given in the plans, provide soil reinforcement with a length that is equal to 70 percent of the wall height but not less than 8 feet (2.4 m). If the wall will be located at an abutment, measure the wall height from the top of the leveling pad to the profile grade elevation at the face of the wall. For all other walls, measure the wall height from the top of the leveling pad to the top of the coping.

3. Use the following soil parameters in the design. These parameters are not to be used for material acceptance.

TABLE 840.04-1

Fill Zone	Type of Soil	Design Soil Unit Weight	Friction Angle	Cohesion
Reinforced Soil	Select Granular Backfill	120 lbs/ft ³ (18.9 kN/m ³)	34°	0
Retained Soil (Soil behind the Reinforced Soil Zone)	On-site soil varying from sandy lean clay to silty sand	120 lbs/ft ³ (18.9 kN/m ³)	30°	0

4. Use the simplified method or the coherent gravity method for internal stability calculations.

5. Include a live load surcharge of 250 psf (12.0 kPa) unless the backfill above the wall is sloped steeper than 4H:1V. Include a live load surcharge even if there is an approach slab at the bridge abutment.

6. Assume a water level within the reinforced soil at the invert elevation of the drainage pipe.

7. Use the following reduction factor values for geosynthetic soil reinforcement.

TABLE 840.04-2

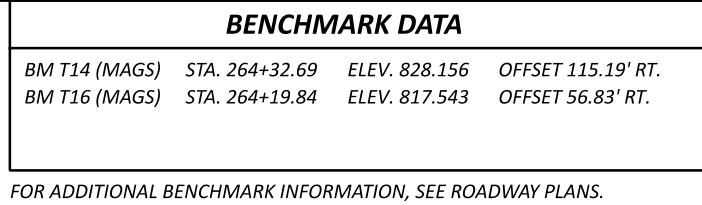
Accredited MSE Wall System	Soil Reinforcement	Reduction Factors		
		Installation Damage RF _{ID}	Creep RF _{CR}	Durability RF _D
GeoMega	Geostrap	1.1	1.5	1.14
Redi-Rock	5XT, 8XT, 10XT	1.6	1.66	1.3
	20XT, 24XT	1.5		
ARES	UX1100MSE	1.31	2.73	1.1
	UX1400MSE	1.33	2.73	
	UX1500MSE	1.34	2.57	
	UX1600MSE	1.37	2.57	
	UX1700MSE	1.39	2.57	

MSE Wall Analyses

Rear Abutment (South)
Wall 001
MSEW Analyses

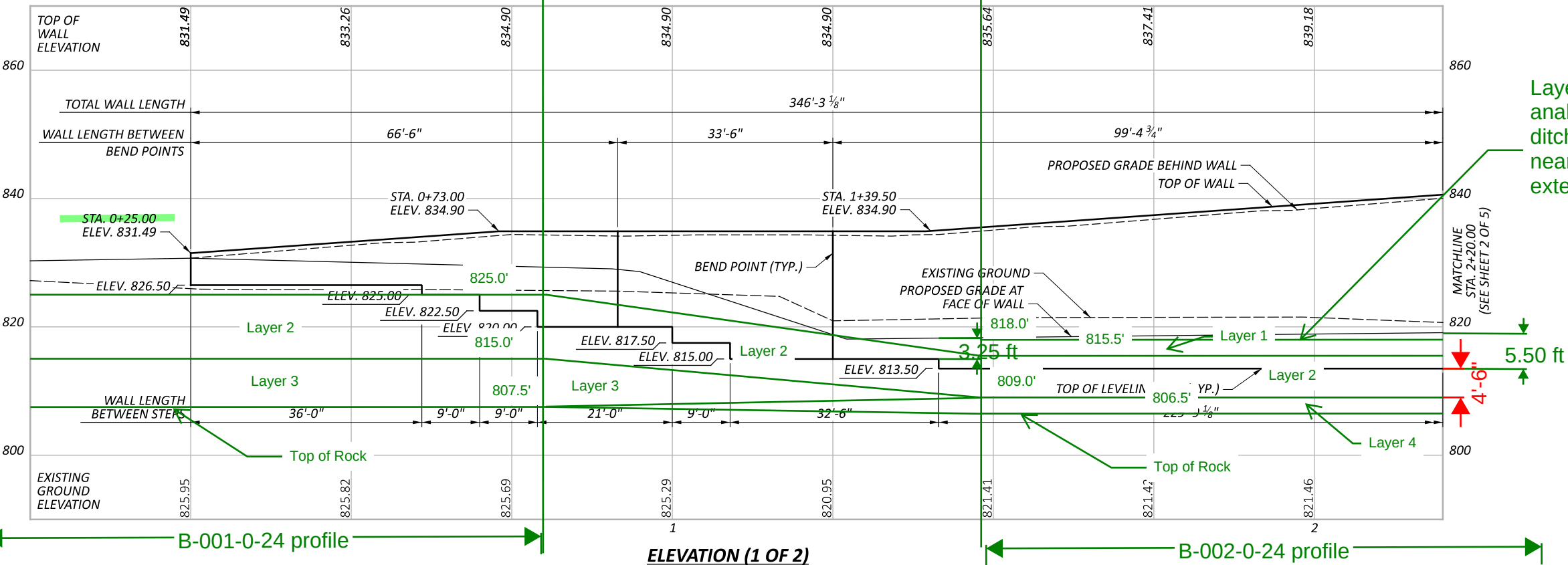
Sta 2+93/Sta 3+18
15.0' Wall

Design Section 1



1. EARTHWORK LIMITS SHOWN ARE APPROXIMATE. ACTUAL SLOPES SHALL CONFORM TO PLAN CROSS SECTIONS.

Design Section 4 (MSE Wall - End Wall - Full Ramp Height)

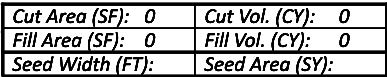


Layer 1 excluded from MSE wall analyses due to boring performed in ditch containing hydrophilic vegetation near US-126. Layer 2 assumed to extend to the existing ground surface.

WALL PLAN AND ELEVATION (1 OF 2)
WALL 001
ALONG SOUTH APPROACH

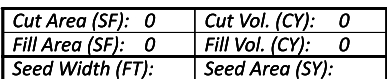
SFN	
N/A	
DESIGN AGENCY	
	
9999 CARVER ROAD SUITE 210 CINCINNATI, OH 45242 513.984.7500	
DESIGNER	CHECKER
RBK	XXX
REVIEWER	
XXX MM-DD-Y	
PROJECT ID	
114652	
SUBSET	TOTAL
1	5
SHEET	TOTAL
P.25	32





DESIGN AGENCY
HDR
DESIGNER
MJL
REVIEWER
XXX MM-DD-YY

STA. 2+74.72 AND STA. 3+37.22, STA. 2+93.72 AND STA. 3+18.22



Design Section 1

Rear Abutment and Walls (South)

MSEW(3.0): Update # 14.4

License number MSEW-302528

SOIL DATA

REINFORCED SOIL

Unit weight, γ	120.0 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	30.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{\text{equiv.}}$	130.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{\text{equiv.}}$	0.0 °
Equivalent cohesion, $c_{\text{equiv.}}$	2400.0 lb/ft ²

Water table is at wall base elevation

LATERAL EARTH PRESSURE COEFFICIENTS

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

Ka (external stability) = 0.3333 (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): $N_c = 5.14$ $N_\gamma = 0.00$

SEISMICITY

Not Applicable

INPUT DATA: Metal strips (Analysis)

D A T A	Metal strip type #1	Metal strip type #2	Metal strip type #3	Metal strip type #4	Metal strip type #5
Yield strength of steel, F_y [kips/in ²]	65.3	N/A	N/A	N/A	N/A
Gross width of strip, b [in]	2.0	N/A	N/A	N/A	N/A
Vertical spacing, S_v [ft]	Varies	N/A	N/A	N/A	N/A
Design cross section area, A_c [in ²]	0.23	N/A	N/A	N/A	N/A

Ribbed steel strips.

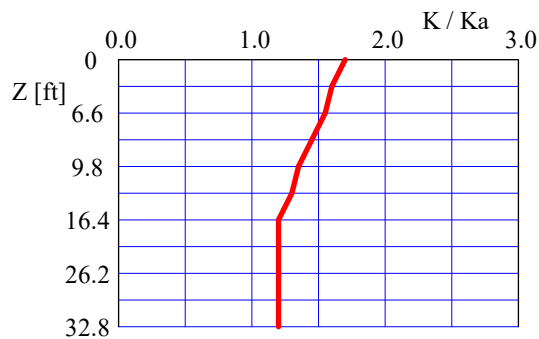
Uniformity Coefficient of reinforced soil, $C_u = D_{60}/D_{10} = 4.0$

Friction angle along reinforcement-soil interface,	ρ				
@ the top	60.97	N/A	N/A	N/A	N/A
@ 19.7 ft or below	32.00	N/A	N/A	N/A	N/A
Pullout resistance factor, F^*					
@ the top	1.80	N/A	N/A	N/A	N/A
@ 19.7 ft or below	0.62	N/A	N/A	N/A	N/A
Scale-effect correction factor, α	1.00	N/A	N/A	N/A	N/A

Note: Z for calculating K/Ka and F* is measured from roadway surface (FHWA-NHI-10-024).

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.70
3.3 ft	1.60
6.6 ft	1.55
9.8 ft	1.45
13.1 ft	1.35
16.4 ft	1.30
19.7 ft	1.20



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

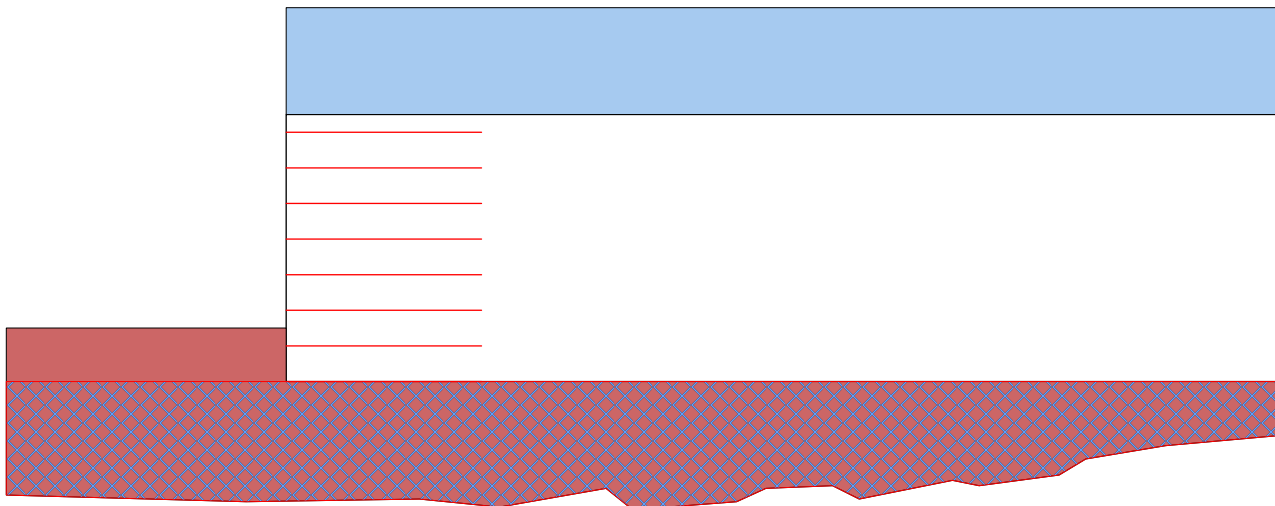
Design height, Hd	15.00	[ft]	{ Embedded depth is E = 3.00 ft, and height above top of finished bottom grade is H = 12.00 ft }
Batter, ω	0.0	[deg]	
Backslope, β	0.0	[deg]	
Backslope rise	0.0	[ft]	Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)

UNIFORM SURCHARGE

Uniformly distributed dead load is 0.0 [lb/ft²], and live load is 250.0 [lb/ft²]

Hydrostatic water pressure exist in analysis. hw1 = 0.00 and hw2 = 0.00 ft.

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 8 10 [ft]



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 γ_{p-EV}	1.00	γ_{p-EQ} 1.00
Bearing Capacity γ_{p-EV}	1.35	γ_{p-EQ} 1.35
Load factor of active lateral earth pressure, EH, from Table 3.4.1-2 and Figure C11.5.5-2:	γ_{p-EH}	1.50
Load factor of active lateral earth pressure during earthquake (does not multiply P_{AE} and P_{IR}):	$(\gamma_{p-EH})_{EQ}$	1.50
Load factor for earthquake loads, EQ, from Table 3.4.1-1 (multiplies P_{AE} and P_{IR}):	γ_{p-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, $CDR = 1.99$, factored bearing load = 4034 lb/ft².

Foundation Interface: Direct sliding, CDR = 1.494, Eccentricity, $e/L = 0.2303$, CDR-overtopping = 2.17

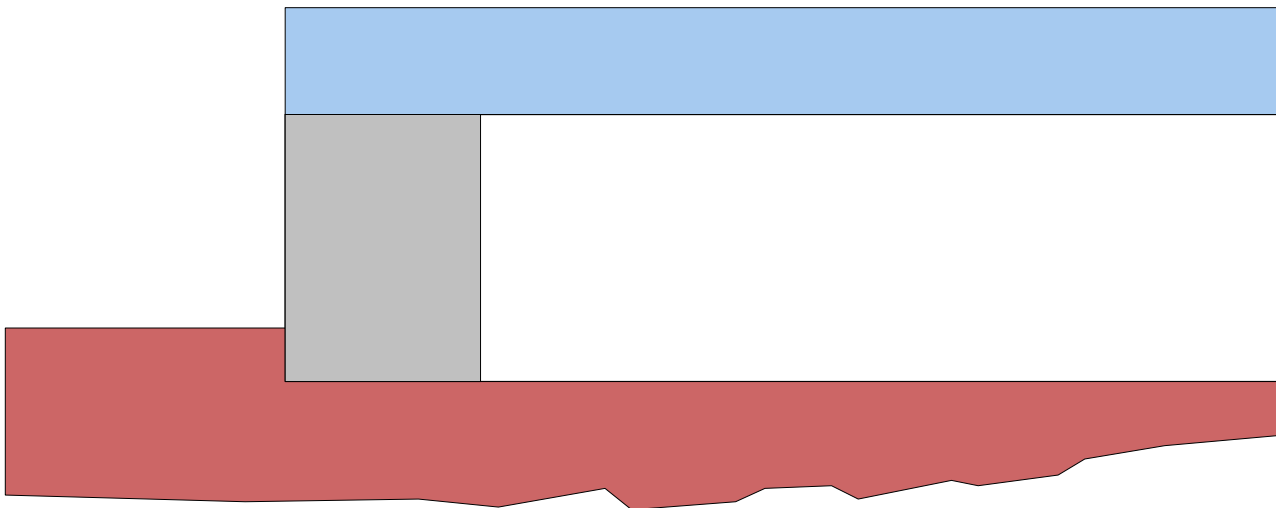
METAL STRIP				CONNECTION							Product name
#	Elevation [ft]	Length [ft]	Type #	CDR [pullout resistance]	CDR [connection break]	CDR [metal strip strength]	Metal strip strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	
1	0.00	11.00	1	N/A	3.98	4.42	4.419	2.053	1.494	0.2303	---
2	2.00	11.00	1	N/A	2.13	2.37	2.367	0.961	1.662	0.1817	---
3	4.00	11.00	1	N/A	2.35	2.61	2.610	0.879	1.871	0.1386	---
4	6.00	11.00	1	N/A	2.64	2.93	2.930	0.767	2.141	0.1010	---
5	8.00	11.00	1	N/A	3.06	3.40	3.404	0.667	2.502	0.0689	---
6	10.00	11.00	1	N/A	3.76	4.17	4.173	0.634	3.010	0.0423	---
7	12.00	11.00	1	N/A	4.95	5.50	5.504	0.542	3.775	0.0213	---
8	14.00	11.00	1	N/A	7.39	8.22	8.215	0.290	5.064	0.0057	---

BEARING CAPACITY for GIVEN LAYOUT

	STATIC	SEISMIC	UNITS
(Water table is at wall base elevation)			
Factored bearing resistance, q-n	8021	N/A	[lb/ft ²]
Factored bearing load, σ_v	4033.7	N/A	[lb/ft ²]
Eccentricity, e	1.59	N/A	[ft]
Eccentricity, e/L	0.145	N/A	
CDR calculated	1.99	N/A	
Base length	11.00	N/A	[ft]

$$\text{Unfactored applied bearing pressure} = (\text{Unfactored R}) / [L - 2 * (\text{Unfactored e})] =$$

Unfactored R = 22549.99 [lb/ft], L = 11.00, Unfactored e = 1.41 [ft], and Sigma = 2759.10 [lb/ft²]



SCALE:

0 2 4 6 8 10 [ft]



DIRECT SLIDING for GIVEN LAYOUT (for METAL STRIPS reinforcements)

Along reinforced and foundation soils interface: CDR-static = 1.494

#	Metal strip Elevation [ft]	Metal strip Length [ft]	CDR Static	CDR Seismic	Metal strip Type #	Product name
1	0.00	11.00	1.494	N/A	1	---
2	2.00	11.00	1.662	N/A	1	---
3	4.00	11.00	1.871	N/A	1	---
4	6.00	11.00	2.141	N/A	1	---
5	8.00	11.00	2.502	N/A	1	---
6	10.00	11.00	3.010	N/A	1	---
7	12.00	11.00	3.775	N/A	1	---
8	14.00	11.00	5.064	N/A	1	---

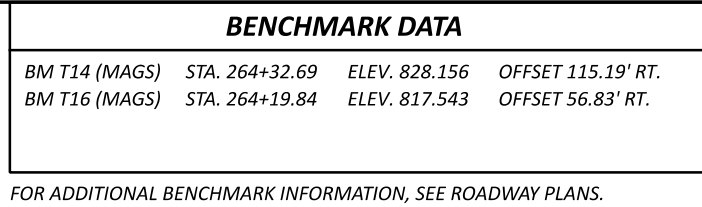
ECCENTRICITY for GIVEN LAYOUT (for Simplified Method)

At interface with foundation: e/L static = 0.2303; Overturning: CDR-static = 2.17

#	Metal strip Elevation [ft]	Metal strip Length [ft]	e / L Static	e / L Seismic	Metal strip Type #	Product name
1	0.00	11.00	0.2303	N/A	1	---
2	2.00	11.00	0.1817	N/A	1	---
3	4.00	11.00	0.1386	N/A	1	---
4	6.00	11.00	0.1010	N/A	1	---
5	8.00	11.00	0.0689	N/A	1	---
6	10.00	11.00	0.0423	N/A	1	---
7	12.00	11.00	0.0213	N/A	1	---
8	14.00	11.00	0.0057	N/A	1	---

Sta 2+93/Sta 3+18
20.0' Wall

Design Section 2

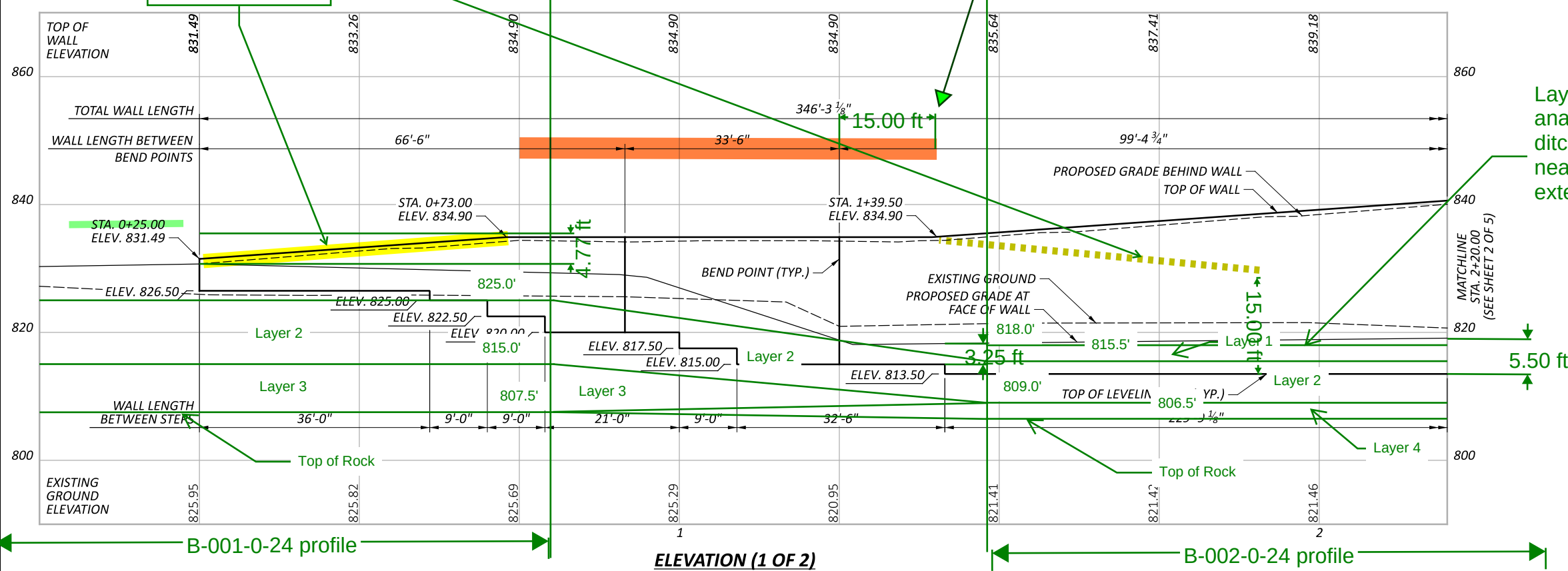


NOTES

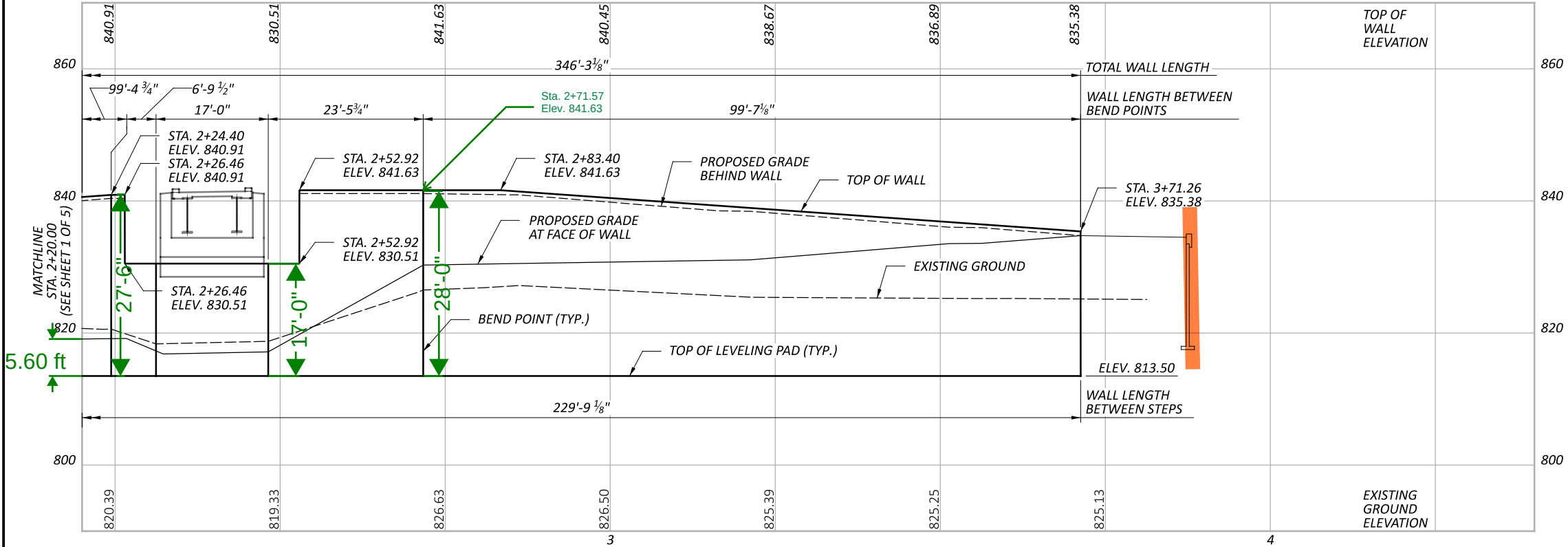
1. EARTHWORK LIMITS SHOWN ARE APPROXIMATE. ACTUAL SLOPES SHALL CONFORM TO PLAN CROSS SECTIONS.

MSE Wall Design Sections:

- Design Section 1
 - MSE Along Ramp Upslope of SR-126
- Design Section 2 (MSE Wall at switch-back)
- Design Section 3
 - MSE Wall Abutment
 - MSE Wall Back-to-back Ramp walls
 - MSE Wall Center Height Back to Back Wall
- Design Section 4 (MSE Wall - End Wall - Full Ramp Height)



Layer 1 excluded from MSE wall analyses due to boring performed in ditch containing hydrophilic vegetation near US-126. Layer 2 assumed to extend to the existing ground surface.



ELEVATION (2 OF 2)

WALL PLAN AND ELEVATION (2 OF 2)
WALL 001
ALONG SOUTH APPROACH

SFN

N/A

DESIGN AGENCY



9999 CARVER ROAD
SUITE 210
CINCINNATI, OH 45242
513.984.7500

DESIGNER

CHECKER

RBK

XXX

REVIEWER

XXX MM-DD-YY

PROJECT ID

114652

SUBSET

TOTAL

2

5

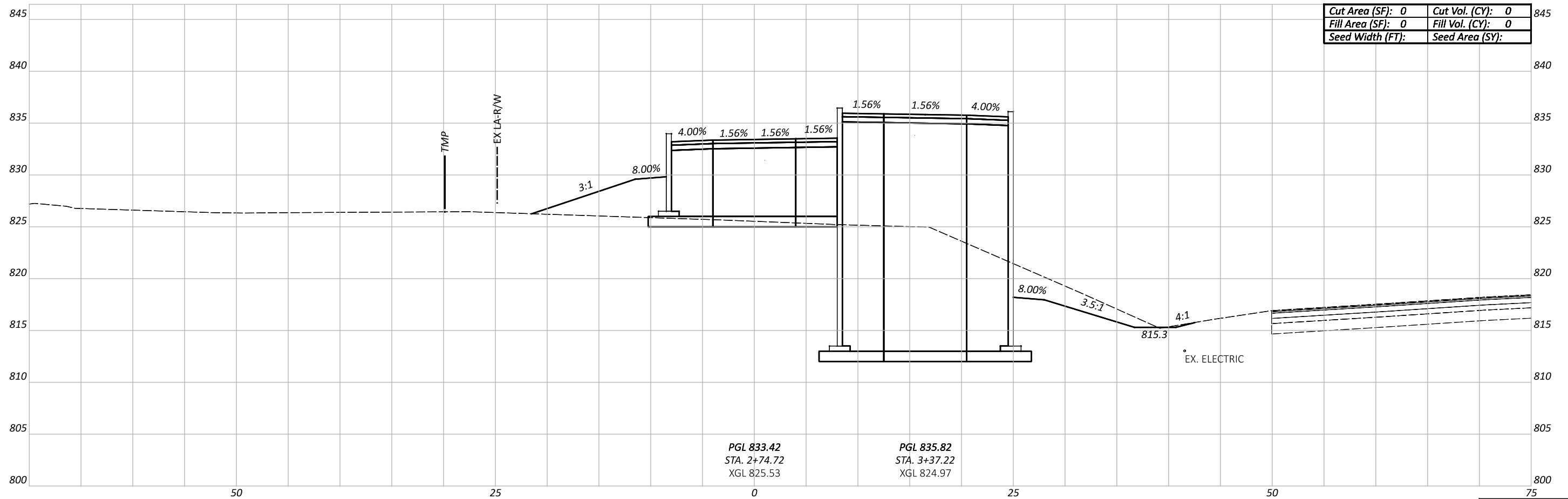
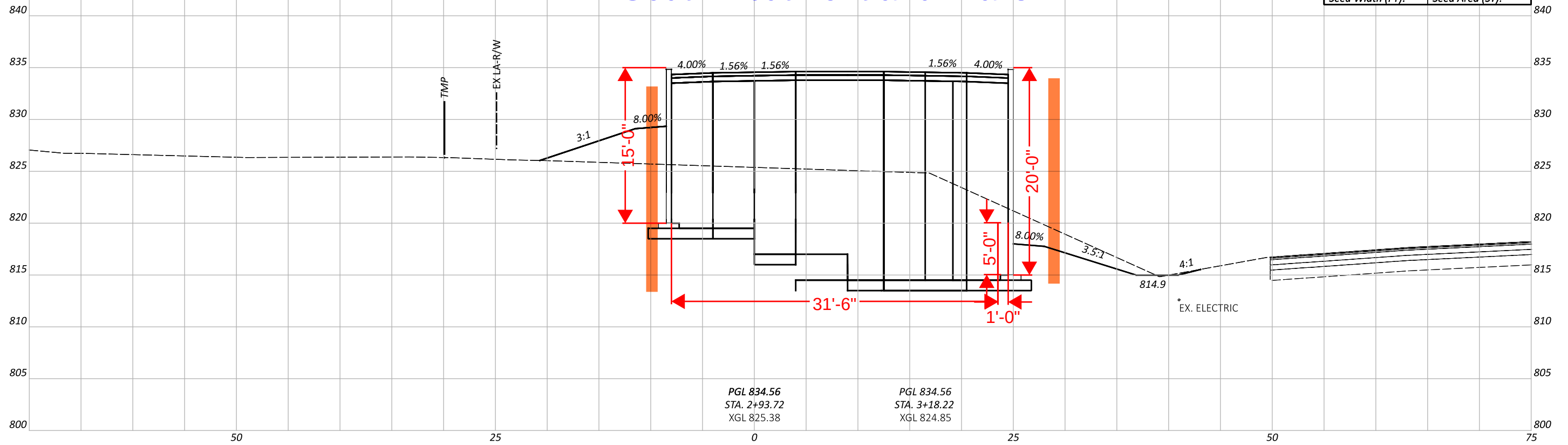
SHEET

TOTAL

P.26

32

South Abutment and Walls



Cut Area (SF): 0	Cut Vol. (CY): 0
Fill Area (SF): 0	Fill Vol. (CY): 0
Seed Width (FT):	Seed Area (SY):

Cut Area (SF): 0	Cut Vol. (CY): 0
Fill Area (SF): 0	Fill Vol. (CY): 0
Seed Width (FT):	Seed Area (SY):

CROSS SECTIONS

STA. 2+74.72 AND STA. 3+37.22, STA. 2+93.72 AND STA. 3+18.22

DESIGN AGENCY



DESIGNER

MJL

REVIEWER

XX MM-DD-YY

PROJECT ID

114652

TOTAL

4 | 32

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
---	---	---	---	---	---	---	---	---	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	-----

MSEW(3.0): Update # 14.4

License number MSEW-302528

SOIL DATA

REINFORCED SOIL

Unit weight, γ	120.0 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	34.0 ° 

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{\text{equiv.}}$	130.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{\text{equiv.}}$	0.0 °
Equivalent cohesion, $c_{\text{equiv.}}$	2400.0 lb/ft ²

Water table is at wall base elevation

LATERAL EARTH PRESSURE COEFFICIENTS

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

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

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): $N_c = 5.14$ $N_\gamma = 0.00$

SEISMICITY

Not Applicable

34*

Retained is the same as Reinforced given the location of the wall at the end of two back to back MSE walls.

INPUT DATA: Metal strips
(Analysis)

D A T A	Metal strip type #1	Metal strip type #2	Metal strip type #3	Metal strip type #4	Metal strip type #5
Yield strength of steel, F_y [kips/in ²]	65.3	N/A	N/A	N/A	N/A
Gross width of strip, b [in]	2.0	N/A	N/A	N/A	N/A
Vertical spacing, S_v [ft]	Varies	N/A	N/A	N/A	N/A
Design cross section area, A_c [in ²]	0.23	N/A	N/A	N/A	N/A

Ribbed steel strips.

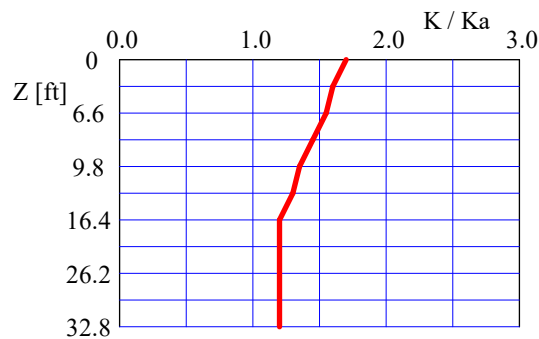
Uniformity Coefficient of reinforced soil, $C_u = D_{60}/D_{10} = 4.0$

Friction angle along reinforcement-soil interface,	ρ				
@ the top	60.97	N/A	N/A	N/A	N/A
@ 19.7 ft or below	32.00	N/A	N/A	N/A	N/A
Pullout resistance factor, F^*					
@ the top	1.80	N/A	N/A	N/A	N/A
@ 19.7 ft or below	0.62	N/A	N/A	N/A	N/A
Scale-effect correction factor, α	1.00	N/A	N/A	N/A	N/A

Note: Z for calculating K/Ka and F* is measured from roadway surface (FHWA-NHI-10-024).

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.70
3.3 ft	1.60
6.6 ft	1.55
9.8 ft	1.45
13.1 ft	1.35
16.4 ft	1.30
19.7 ft	1.20



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

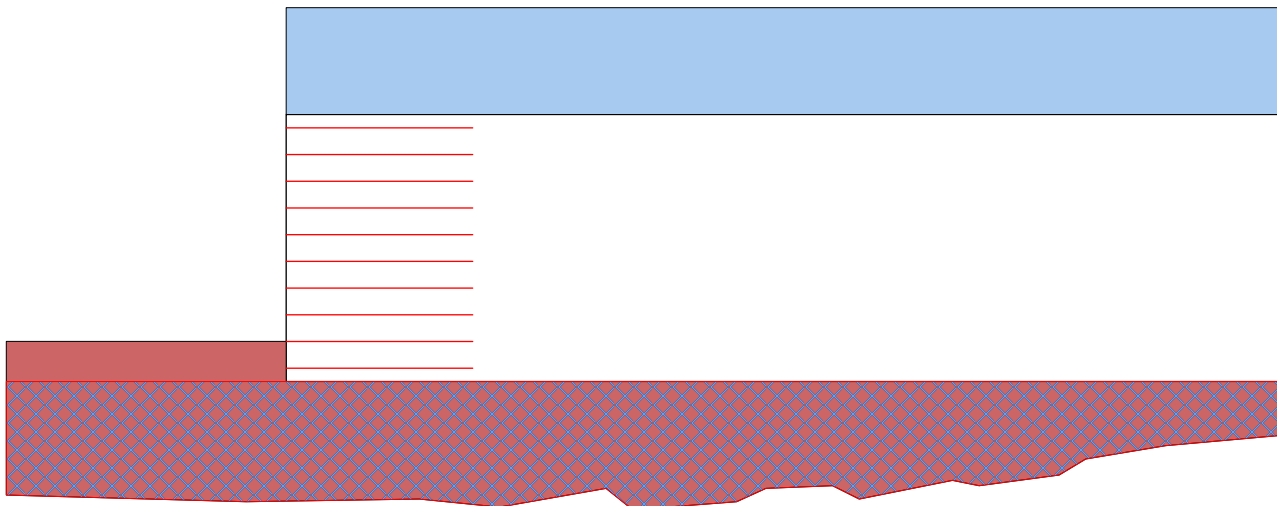
Design height, Hd	20.00	[ft]	{ Embedded depth is E = 3.00 ft, and height above top of finished bottom grade is H = 17.00 ft }
Batter, ω	0.0	[deg]	
Backslope, β	0.0	[deg]	
Backslope rise	0.0	[ft]	Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)

UNIFORM SURCHARGE

Uniformly distributed dead load is 0.0 [lb/ft²], and live load is 250.0 [lb/ft²]

Hydrostatic water pressure exist in analysis. hw1 = 0.00 and hw2 = 0.00 ft.

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:	γ_{p-EV}	1.35	
Load factor for earthquake loads, EQ, from Table 3.4.1-1:	γ_{p-EQ}	1.00	
Load factor for live load surchrge, LS, from Figure C11.5.5-3(b): (Same as in External Stability).	γ_{p-LS}	1.75	
Load factor for dead load surchrge, ES: (Same as in External Stability).	γ_{p-ES}	1.50	
Resistance factor for reinforcement tension from Table 11.5.6-1: Metal Strips:	ϕ	Static 0.75	Combined static/seismic 1.00
Resistance factor for reinforcement tension in connectors from Table 11.5.6-1: Metal Strips:	ϕ	Static 0.75	Combined static/seismic 1.00
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 γ_{p-EV}	1.00	γ_{p-EQ} 1.00
Bearing Capacity γ_{p-EV}	1.35	γ_{p-EQ} 1.35
Load factor of active lateral earth pressure, EH, from Table 3.4.1-2 and Figure C11.5.5-2:	γ_{p-EH}	1.50
Load factor of active lateral earth pressure during earthquake (does not multiply P_{AE} and P_{IR}):	$(\gamma_{p-EH})_{EQ}$	1.50
Load factor for earthquake loads, EQ, from Table 3.4.1-1 (multiplies P_{AE} and P_{IR}):	γ_{p-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)

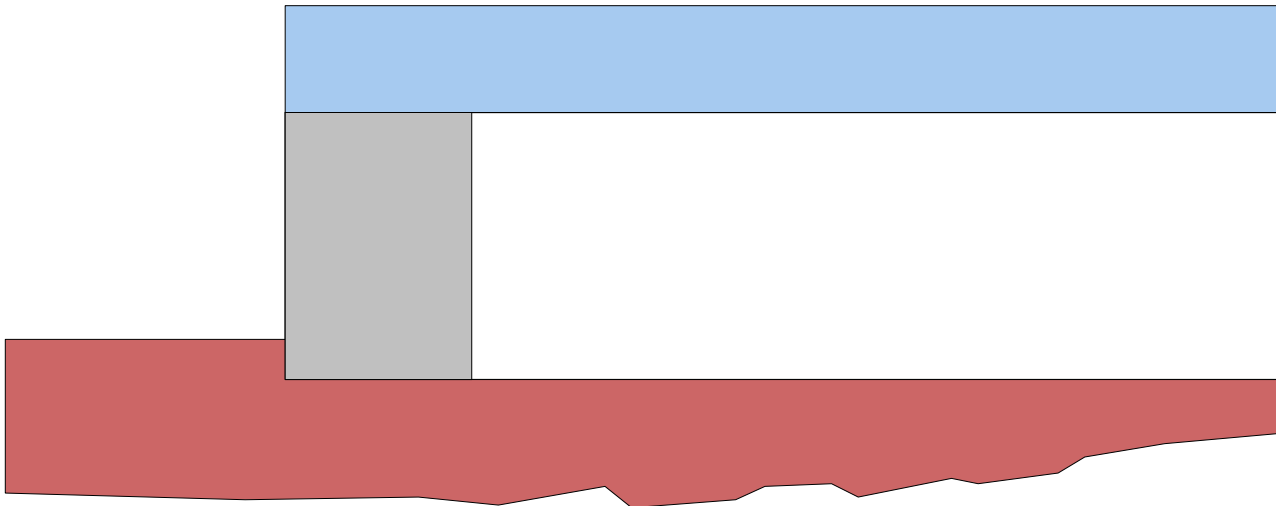
Bearing capacity, CDR = 1.62, factored bearing load = 4949 lb/ft².

Foundation Interface: Direct sliding, CDR = 1.791, Eccentricity, $e/L = 0.1968$, CDR-overtopping = 2.54

METAL STRIP				CONNECTION							Product name
#	Elevation [ft]	Length [ft]	Type #	CDR [pullout resistance]	CDR [connection break]	CDR [metal strip strength]	Metal strip strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	
1	1.00	14.00	1	N/A	1.71	1.90	1.901	1.001	1.862	0.1801	---
2	3.00	14.00	1	N/A	1.81	2.01	2.007	1.016	2.037	0.1489	---
3	5.00	14.00	1	N/A	1.94	2.16	2.161	1.003	2.242	0.1206	---
4	7.00	14.00	1	N/A	2.13	2.37	2.367	0.961	2.493	0.0951	---
5	9.00	14.00	1	N/A	2.35	2.61	2.610	0.879	2.808	0.0726	---
6	11.00	14.00	1	N/A	2.64	2.93	2.930	0.829	3.213	0.0529	---
7	13.00	14.00	1	N/A	3.06	3.40	3.404	0.820	3.755	0.0361	---
8	15.00	14.00	1	N/A	3.76	4.17	4.173	0.780	4.516	0.0222	---
9	17.00	14.00	1	N/A	4.95	5.50	5.504	0.667	5.665	0.0111	---
10	19.00	14.00	1	N/A	7.39	8.22	8.215	0.356	7.598	0.0030	---

BEARING CAPACITY for GIVEN LAYOUT

	STATIC	SEISMIC	UNITS
(Water table is at wall base elevation)			
Factored bearing resistance, q-n	8021	N/A	[lb/ft ²]
Factored bearing load, σ _v	4948.9	N/A	[lb/ft ²]
Eccentricity, e	1.80	N/A	[ft]
Eccentricity, e/L	0.128	N/A	
CDR calculated	1.62	N/A	
Base length	14.00	N/A	[ft]
Unfactored applied bearing pressure = (Unfactored R) / [L - 2 * (Unfactored e)] = Unfactored R = 37099.98 [lb/ft], L = 14.00, Unfactored e = 1.60 [ft], and Sigma = 3435.36 [lb/ft ²]			



SCALE:

0 2 4 6 8 10 [ft]



DIRECT SLIDING for GIVEN LAYOUT (for METAL STRIPS reinforcements)

Along reinforced and foundation soils interface: CDR-static = 1.791

#	Metal strip Elevation [ft]	Metal strip Length [ft]	CDR Static	CDR Seismic	Metal strip Type #	Product name
1	1.00	14.00	1.862	N/A	1	---
2	3.00	14.00	2.037	N/A	1	---
3	5.00	14.00	2.242	N/A	1	---
4	7.00	14.00	2.493	N/A	1	---
5	9.00	14.00	2.808	N/A	1	---
6	11.00	14.00	3.213	N/A	1	---
7	13.00	14.00	3.755	N/A	1	---
8	15.00	14.00	4.516	N/A	1	---
9	17.00	14.00	5.665	N/A	1	---
10	19.00	14.00	7.598	N/A	1	---

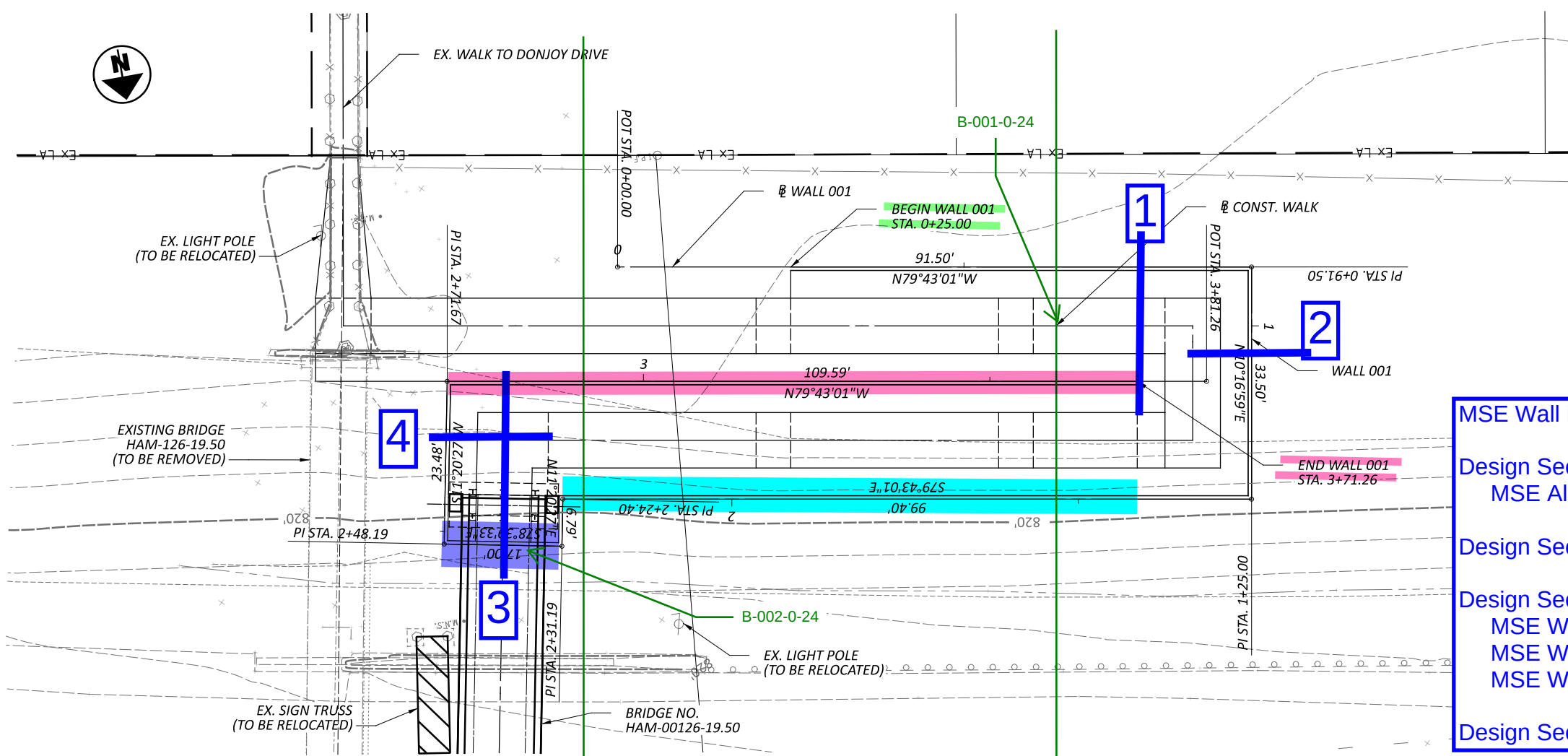
ECCENTRICITY for GIVEN LAYOUT (for Simplified Method)

At interface with foundation: e/L static = 0.1968; Overturning: CDR-static = 2.54

#	Metal strip Elevation [ft]	Metal strip Length [ft]	e / L Static	e / L Seismic	Metal strip Type #	Product name
1	1.00	14.00	0.1801	N/A	1	---
2	3.00	14.00	0.1489	N/A	1	---
3	5.00	14.00	0.1206	N/A	1	---
4	7.00	14.00	0.0951	N/A	1	---
5	9.00	14.00	0.0726	N/A	1	---
6	11.00	14.00	0.0529	N/A	1	---
7	13.00	14.00	0.0361	N/A	1	---
8	15.00	14.00	0.0222	N/A	1	---
9	17.00	14.00	0.0111	N/A	1	---
10	19.00	14.00	0.0030	N/A	1	---

Sta 2+04/Sta 4+07
12.5' Wall
(Back to Back)

Design Section 3

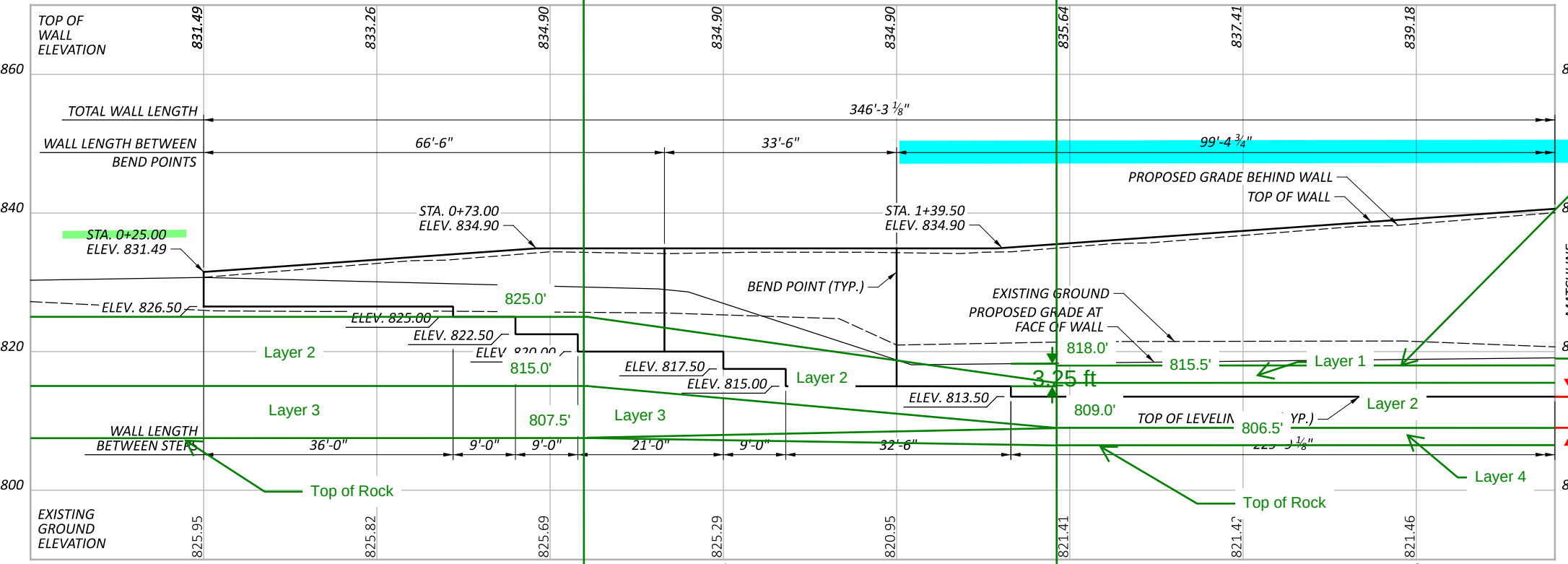


BENCHMARK DATA			
BM T14 (MAGS)	STA. 264+32.69	ELEV. 828.156	OFFSET 115.19' RT.
BM T16 (MAGS)	STA. 264+19.84	ELEV. 817.543	OFFSET 56.83' RT.

FOR ADDITIONAL BENCHMARK INFORMATION, SEE ROADWAY PLANS.

- NOTES**
- EARTHWORK LIMITS SHOWN ARE APPROXIMATE. ACTUAL SLOPES SHALL CONFORM TO PLAN CROSS SECTIONS.

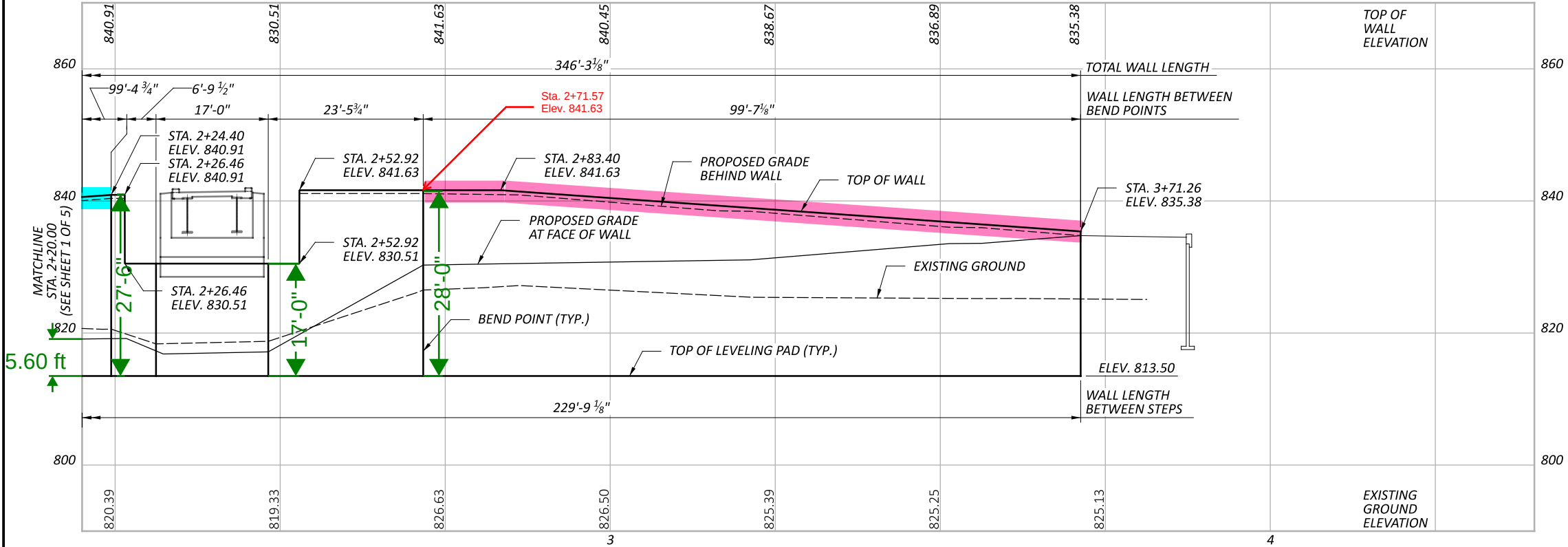
- MSE Wall Design Sections:
- Design Section 1
MSE Along Ramp Upslope of SR-126
 - Design Section 2 (MSE Wall at switch-back)
 - Design Section 3
MSE Wall Abutment
MSE Wall Back-to-back Ramp walls
MSE Wall Center Height Back to Back Wall
 - Design Section 4 (MSE Wall - End Wall - Full Ramp Height)



Layer 1 excluded from MSE wall analyses due to boring performed in ditch containing hydrophilic vegetation near US-126. Layer 2 assumed to extend to the existing ground surface.

WALL PLAN AND ELEVATION (1 OF 2)
WALL 001
ALONG SOUTH APPROACH

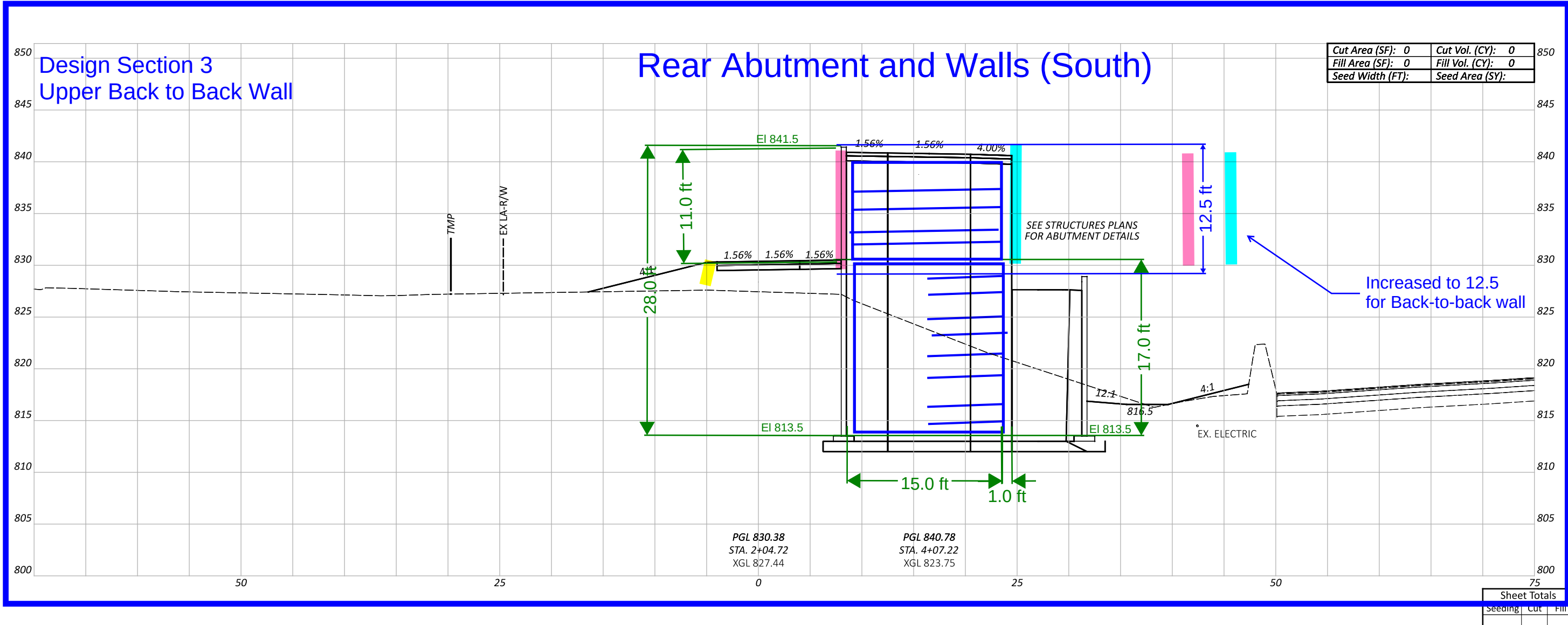
SFN	N/A
DESIGN AGENCY	
DESIGNER	RBK
CHECKER	XXX
REVIEWER	XXX
PROJECT ID	114652
SUBSET	TOTAL
1	5
SHEET	TOTAL
P.25	32

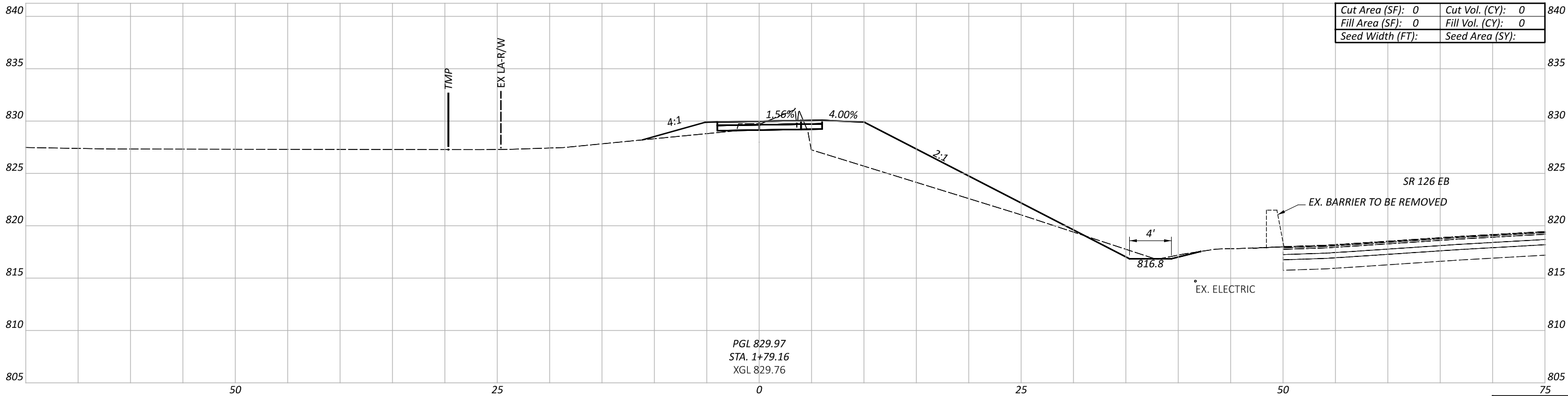
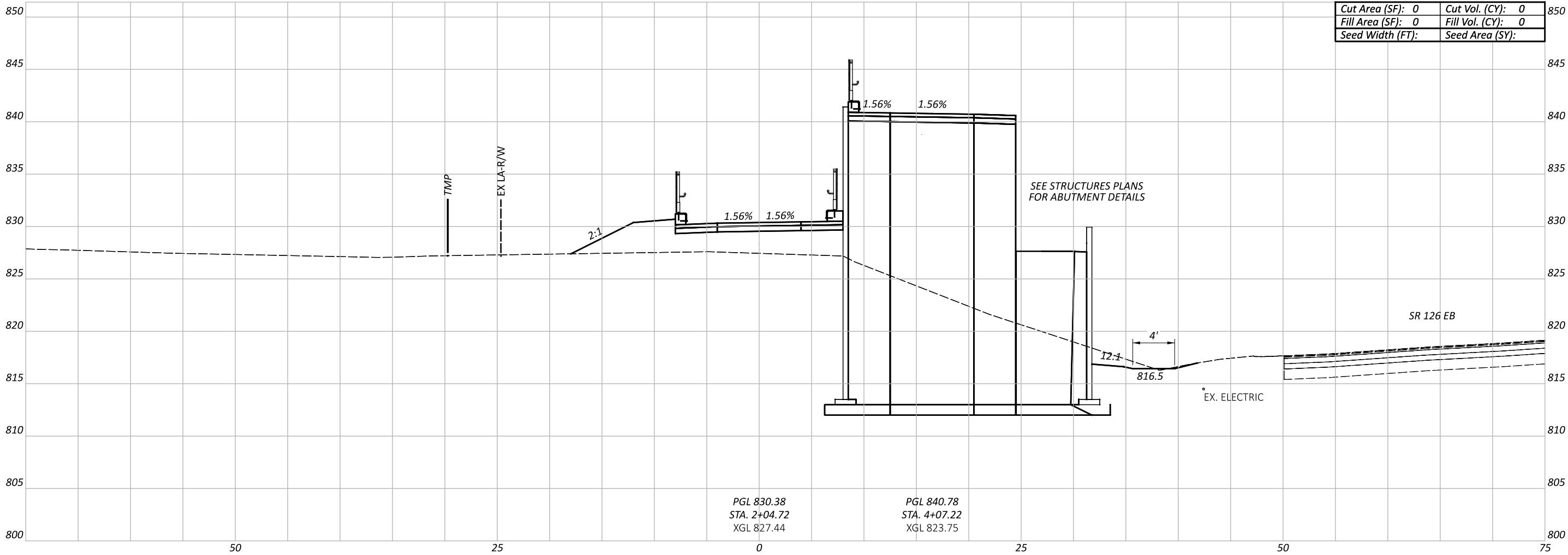


ELEVATION (2 OF 2)

WALL PLAN AND ELEVATION (2 OF 2)
WALL 001
ALONG SOUTH APPROACH

SFN		N/A
DESIGN AGENCY		 9999 CARVER ROAD SUITE 210 CINCINNATI, OH 45242 513.984.7500
DESIGNER	CHECKER	
RBK	XXX	
REVIEWER		XXX MM-DD-YY
PROJECT ID		114652
SUBSET	TOTAL	
2	5	
SHEET	TOTAL	
P.26	32	





Sheet Totals		
Seeding	Cut	Fill

CROSS SECTIONS
TA. 1+79.16, STA. 2+04.72/STA. 4+07.22

DESIGN AGENCY



DESIGNER

MJL

REVIEWER

KF 09/20/24

PROJECT ID

114652

SHEET

P.12

TOTAL

32

MSEW(3.0): Update # 14.4

License number MSEW-302528

License number MSEW-302528

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

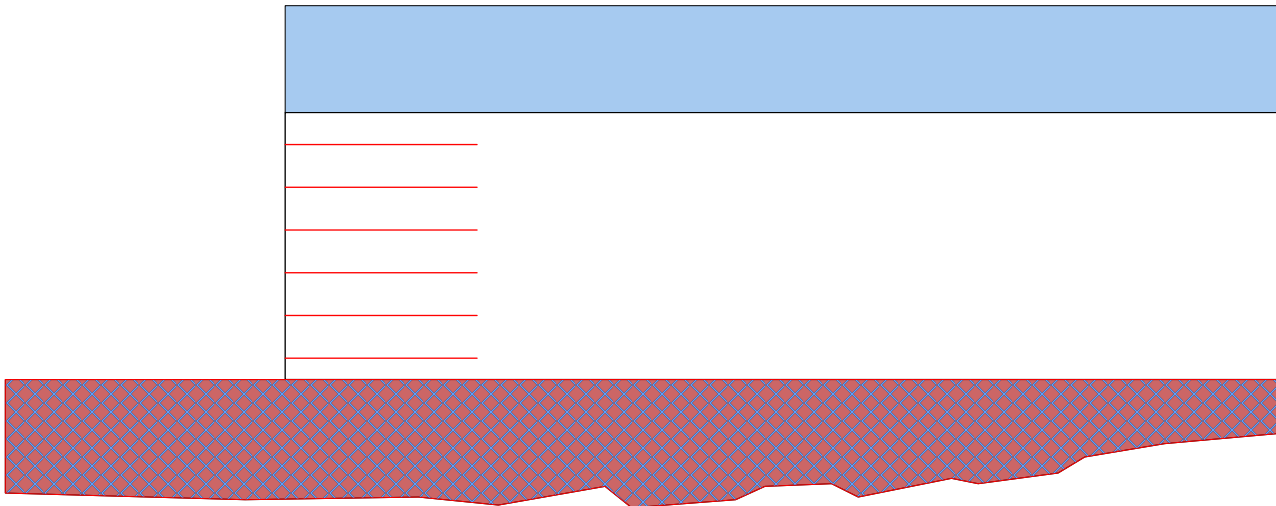
Design height, Hd	12.50 [ft]	{ Embedded depth is E = 0.00 ft, and height above top of finished bottom grade is H = 12.50 ft }
Batter, ω	0.0 [deg]	
Backslope, β	0.0 [deg]	Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)
Backslope rise	0.0 [ft]	

UNIFORM SURCHARGE

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

Hydrostatic water pressure exist in analysis. hw1 = 0.00 and hw2 = 0.00 ft.

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:	γ_{p-EV}	1.35	
Load factor for earthquake loads, EQ, from Table 3.4.1-1:	γ_{p-EQ}	1.00	
Load factor for live load surchrge, LS, from Figure C11.5.5-3(b): (Same as in External Stability).	γ_{p-LS}	1.75	
Load factor for dead load surchrge, ES: (Same as in External Stability).	γ_{p-ES}	1.50	
Resistance factor for reinforcement tension from Table 11.5.6-1: Metal Strips:	ϕ	Static 0.75	Combined static/seismic 1.00
Resistance factor for reinforcement tension in connectors from Table 11.5.6-1: Metal Strips:	ϕ	Static 0.75	Combined static/seismic 1.00
Resistance factor for reinforcement pullout from Table 11.5.6-1:	ϕ	0.90	1.20

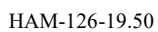
EXTERNAL STABILITY

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 γ_{p-EV}	1.00	γ_{p-EQ} 1.00
Bearing Capacity γ_{p-EV}	1.35	γ_{p-EQ} 1.35
Load factor of active lateral earth pressure, EH, from Table 3.4.1-2 and Figure C11.5.5-2:	γ_{p-EH}	1.50
Load factor of active lateral earth pressure during earthquake (does not multiply P_{AE} and P_{IR}):	$(\gamma_{p-EH})_{EQ}$	1.50
Load factor for earthquake loads, EQ, from Table 3.4.1-1 (multiplies P_{AE} and P_{IR}):	γ_{p-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

BEARING CAPACITY for GIVEN LAYOUT

(Water table is at wall base elevation)

Unfactored R = 15749.99 [lb/ft], L = 9.00, Unfactored e = 1.24 [ft], and Sigma = 2415.70 [lb/ft²]



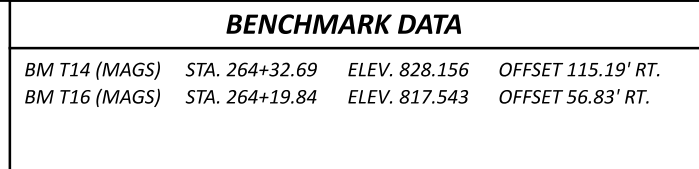
DIRECT SLIDING for GIVEN LAYOUT (for METAL STRIPS reinforcements)

Along reinforced and foundation soils interface: CDR-static = 1.399

#	Metal strip Elevation [ft]	Metal strip Length [ft]	CDR Static	CDR Seismic	Metal strip Type #	Product name
1	1.00	9.00	1.484	N/A	1	---
2	3.00	9.00	1.691	N/A	1	---
3	5.00	9.00	1.964	N/A	1	---
4	7.00	9.00	2.344	N/A	1	---
5	9.00	9.00	2.904	N/A	1	---
6	11.00	9.00	3.817	N/A	1	---

Sta 2+04/Sta 4+07
17.0' Wall
(Abutment)

Design Section 3



FOR ADDITIONAL BENCHMARK INFORMATION, SEE ROADWAY PLANS.

NOTES

1. EARTHWORK LIMITS SHOWN ARE APPROXIMATE. ACTUAL SLOPES SHALL CONFORM TO PLAN CROSS SECTIONS.

MSE Wall Design Sections:

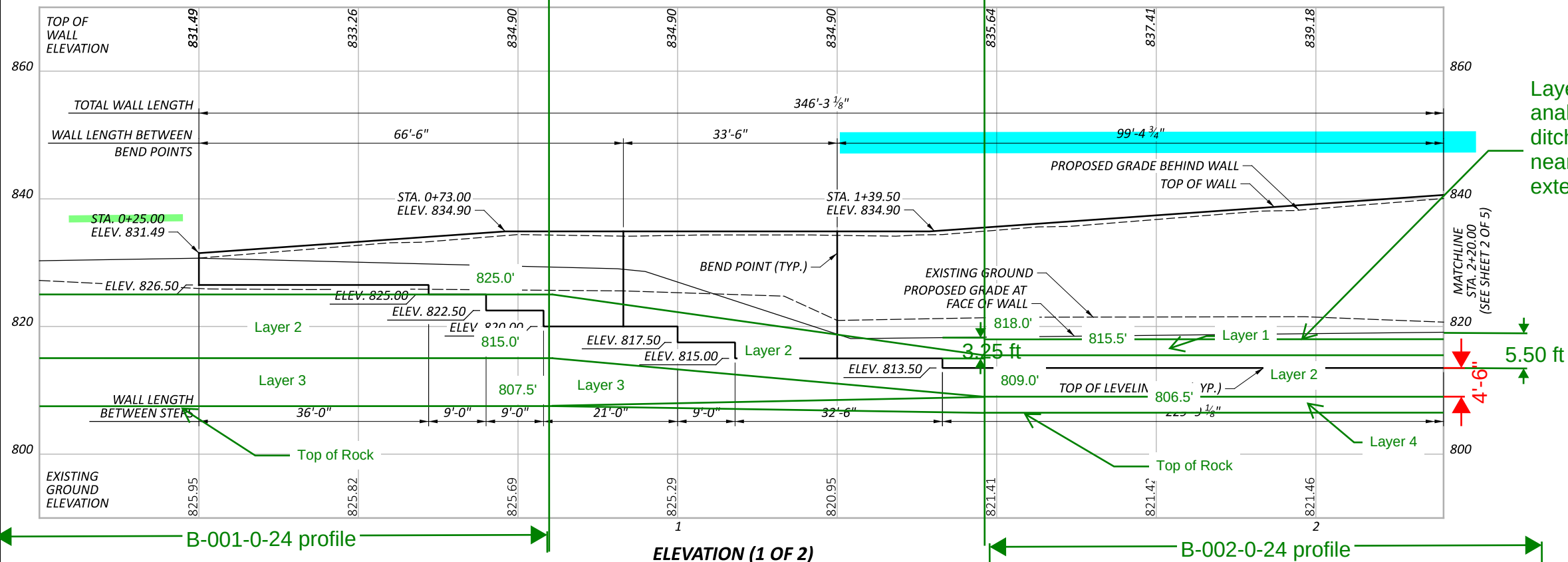
Design Section 1

MSE Along Ramp Upslope of SR-126

Design Section 2 (MSE Wall at switch-back)

Design Section 3
MSE Wall Abutment
MSE Wall Back-to-back Ramp walls
MSE Wall Center Height Back to Back Wall

Design Section 4 (MSE Wall - End Wall - Full Ramp Height)



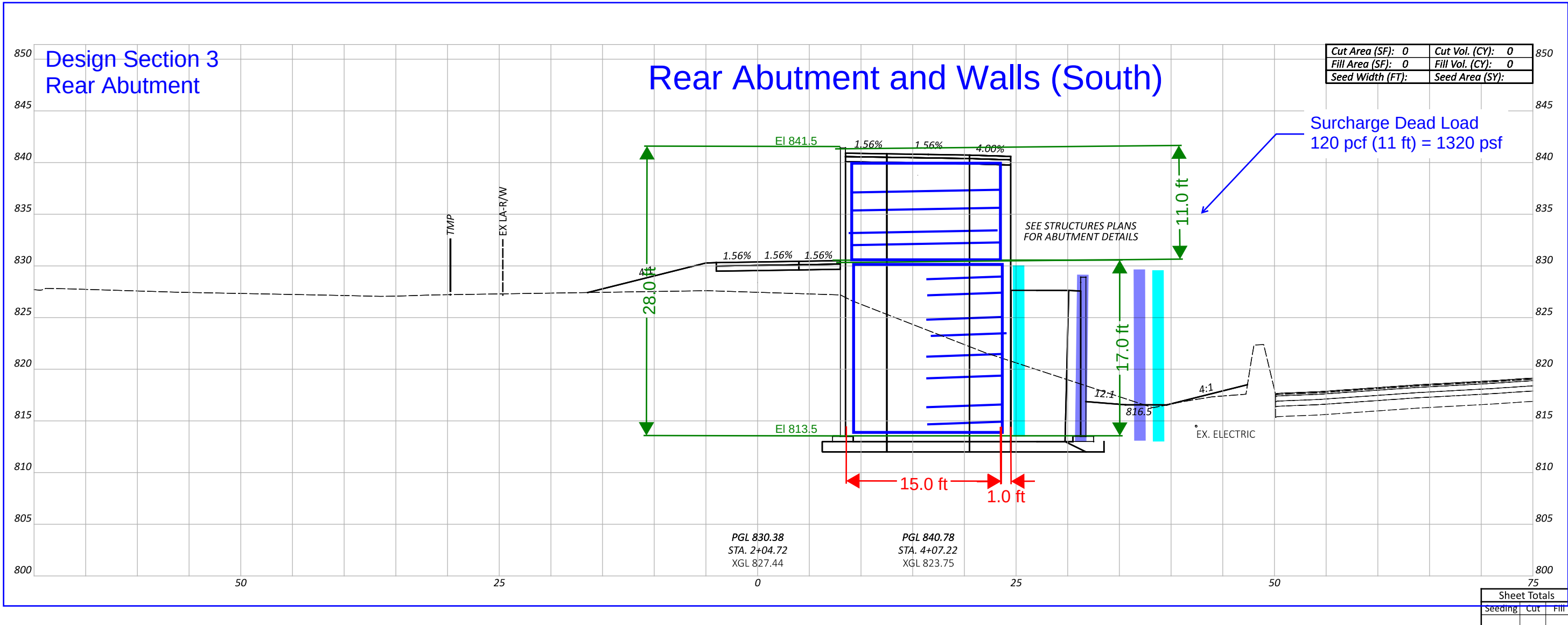
Layer 1 excluded from MSE wall analyses due to boring performed in ditch containing hydrophilic vegetation near US-126. Layer 2 assumed to extend to the existing ground surface.

WALL PLAN AND ELEVATION (1 OF 2)
WALL 001
ALONG SOUTH APPROACH

SFN
N/A
DESIGN AGENCY
HDR
9999 CARVER ROAD
SUITE 210
CINCINNATI, OH 45242
513.984.7500

DESIGNER RBK	CHECKER XXX
REVIEWER XXX MM-DD-Y	
PROJECT ID 114652	
SUBSET 1	TOTAL 5
SHEET P.25	TOTAL 32





INPUT DATA: Metal strips
(Analysis)

D A T A	Metal strip type #1	Metal strip type #2	Metal strip type #3	Metal strip type #4	Metal strip type #5
Yield strength of steel, F_y [kips/in ²]	65.3	N/A	N/A	N/A	N/A
Gross width of strip, b [in]	2.0	N/A	N/A	N/A	N/A
Vertical spacing, S_v [ft]	Varies	N/A	N/A	N/A	N/A
Design cross section area, A_c [in ²]	0.23	N/A	N/A	N/A	N/A

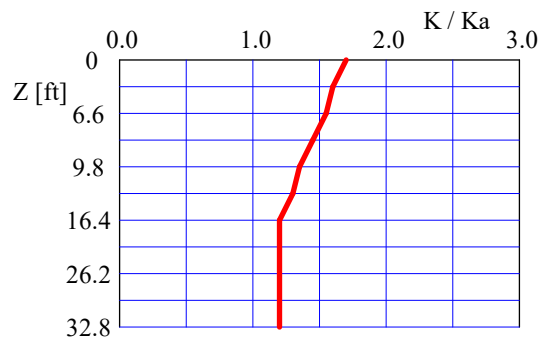
Smooth steel strips.

Friction angle along reinforcement-soil interface,	ρ				
@ the top	17.35	N/A	N/A	N/A	N/A
@ 19.7 ft or below	17.35	N/A	N/A	N/A	N/A
Pullout resistance factor, F^*					
@ the top	0.31	N/A	N/A	N/A	N/A
@ 19.7 ft or below	0.31	N/A	N/A	N/A	N/A
Scale-effect correction factor, α	1.00	N/A	N/A	N/A	N/A

Note: Z for calculating K/Ka and F* is measured from roadway surface (FHWA-NHI-10-024).

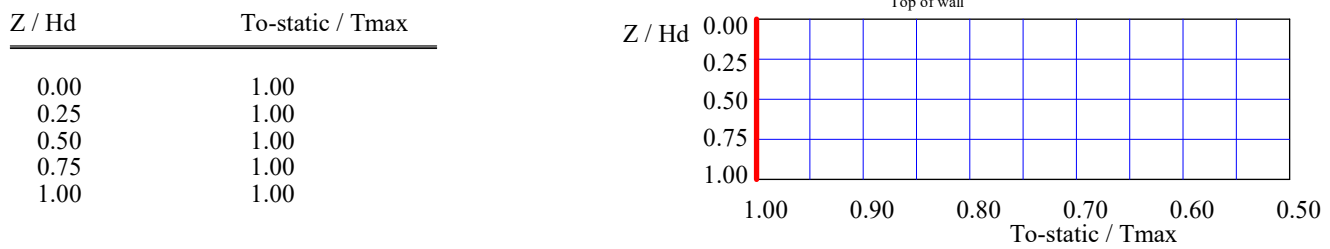
Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.70
3.3 ft	1.60
6.6 ft	1.55
9.8 ft	1.45
13.1 ft	1.35
16.4 ft	1.30
19.7 ft	1.20



INPUT DATA: Facia and Connection (Analysis)

FACIA type: Segmental precast concrete panels.
 Depth of panel is 0.50 ft. Horizontal distance to Center of Gravity of panel is 0.25 ft.
 Average unit weight of panel is $\gamma_f = 152.78 \text{ lb/ft}^3$



D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	---	N/A	N/A	N/A	N/A
Strength reduction at the connection, CRu = Fyc / Fy	0.90	N/A	N/A	N/A	N/A

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

Design height, Hd	17.00	[ft]	{ Embedded depth is E = 3.00 ft, and height above top of finished bottom grade is H = 14.00 ft }
Batter, ω	0.0	[deg]	
Backslope, β	0.0	[deg]	
Backslope rise	0.0	[ft]	
			Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)

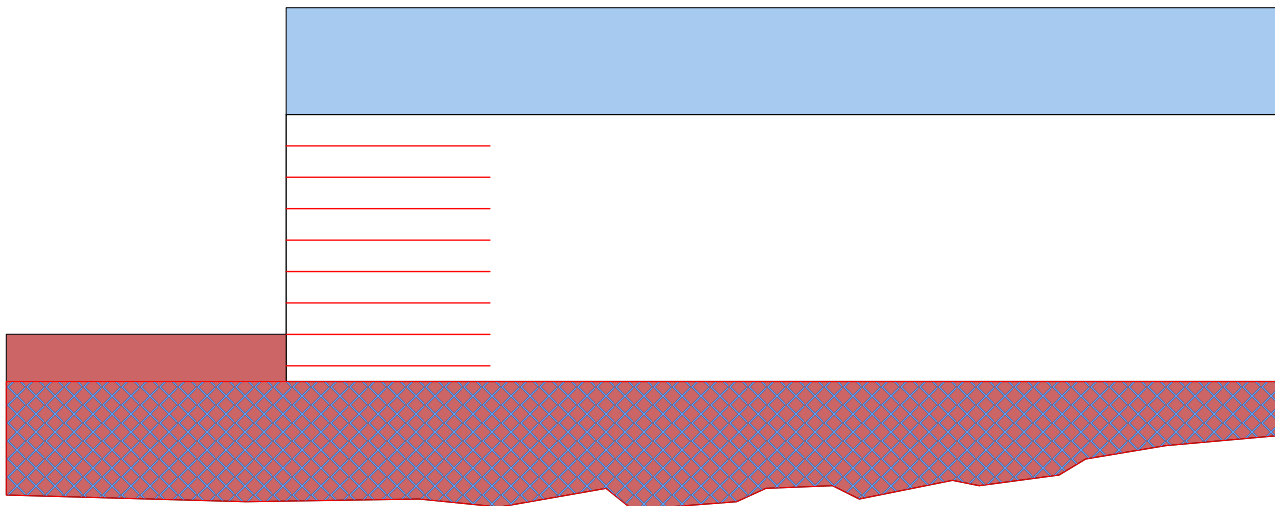
UNIFORM SURCHARGE

Uniformly distributed dead load is 1320.0 [lb/ft ²], and live load is 250.0 [lb/ft ²]

Hydrostatic water pressure exist in analysis. hw1 = 0.00 and hw2 = 0.00 ft.

Surcharge Dead Load
120 pcf x (11 ft) = 1320 psf

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:	γ_{p-EV}	1.35	
Load factor for earthquake loads, EQ, from Table 3.4.1-1:	γ_{p-EQ}	1.00	
Load factor for live load surchrge, LS, from Figure C11.5.5-3(b): (Same as in External Stability).	γ_{p-LS}	1.75	
Load factor for dead load surchrge, ES: (Same as in External Stability).	γ_{p-ES}	1.50	
Resistance factor for reinforcement tension from Table 11.5.6-1: Metal Strips:	ϕ	Static 0.75	Combined static/seismic 1.00
Resistance factor for reinforcement tension in connectors from Table 11.5.6-1: Metal Strips:	ϕ	Static 0.75	Combined static/seismic 1.00
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 γ_{p-EV}	1.00	γ_{p-EQ} 1.00
Bearing Capacity γ_{p-EV}	1.35	γ_{p-EQ} 1.35
Load factor of active lateral earth pressure, EH, from Table 3.4.1-2 and Figure C11.5.5-2:	γ_{p-EH}	1.50
Load factor of active lateral earth pressure during earthquake (does not multiply P_{AE} and P_{IR}):	$(\gamma_{p-EH})_{EQ}$	1.50
Load factor for earthquake loads, EQ, from Table 3.4.1-1 (multiplies P_{AE} and P_{IR}):	γ_{p-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, $CDR = 1.61$, factored bearing load = 8326 lb/ft².

Foundation Interface: Direct sliding, CDR = 1.317, Eccentricity, $e/L = 0.2916$, CDR-overtopping = 1.71

METAL STRIP				CONNECTION							Product name
#	Elevation [ft]	Length [ft]	Type #	CDR [pullout resistance]	CDR [connection break]	CDR [metal strip strength]	Metal strip strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	
1	1.00	13.00	1	N/A	1.13	1.26	1.255	0.408	1.331	0.2632	---
2	3.00	13.00	1	N/A	1.18	1.31	1.306	0.355	1.478	0.2099	---
3	5.00	13.00	1	N/A	1.22	1.36	1.356	0.303	1.668	0.1614	---
4	7.00	13.00	1	N/A	1.26	1.40	1.403	0.252	1.927	0.1181	---
5	9.00	13.00	1	N/A	1.32	1.46	1.464	0.213	2.304	0.0802	---
6	11.00	13.00	1	N/A	1.40	1.55	1.553	0.203	2.916	0.0483	---
7	13.00	13.00	1	N/A	1.51	1.68	1.678	0.193	4.109	0.0233	---
8	15.00	13.00	1	N/A	1.12	1.24	1.242	0.124	7.617	0.0064	---

DIRECT SLIDING for GIVEN LAYOUT (for METAL STRIPS reinforcements)

Along reinforced and foundation soils interface: CDR-static = 1.317

#	Metal strip Elevation [ft]	Metal strip Length [ft]	CDR Static	CDR Seismic	Metal strip Type #	Product name
1	1.00	13.00	1.331	N/A	1	---
2	3.00	13.00	1.478	N/A	1	---
3	5.00	13.00	1.668	N/A	1	---
4	7.00	13.00	1.927	N/A	1	---
5	9.00	13.00	2.304	N/A	1	---
6	11.00	13.00	2.916	N/A	1	---
7	13.00	13.00	4.109	N/A	1	---
8	15.00	13.00	7.617	N/A	1	---

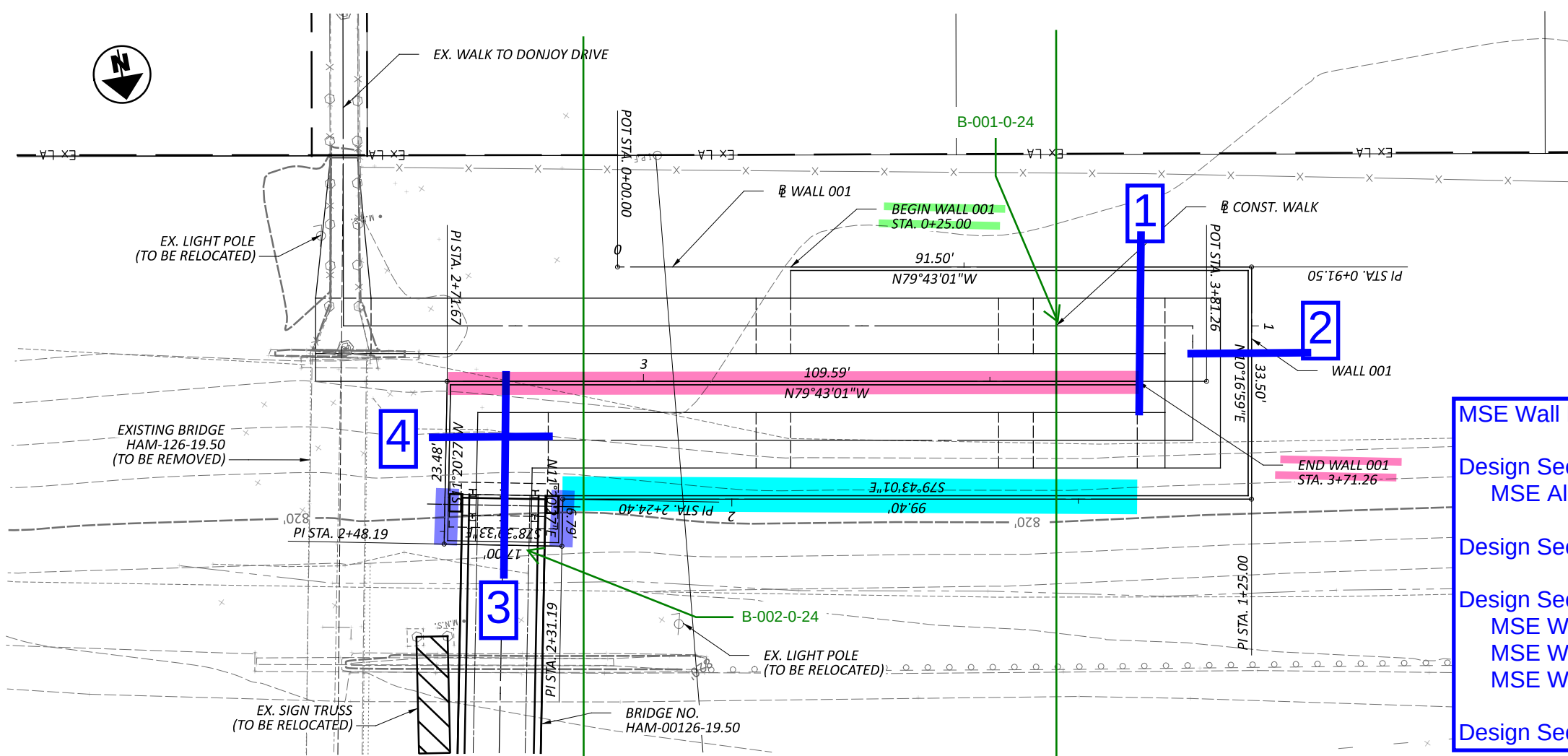
ECCENTRICITY for GIVEN LAYOUT (for Simplified Method)

At interface with foundation: e/L static = 0.2916; Overturning: CDR-static = 1.71

#	Metal strip Elevation [ft]	Metal strip Length [ft]	e / L Static	e / L Seismic	Metal strip Type #	Product name
1	1.00	13.00	0.2632	N/A	1	---
2	3.00	13.00	0.2099	N/A	1	---
3	5.00	13.00	0.1614	N/A	1	---
4	7.00	13.00	0.1181	N/A	1	---
5	9.00	13.00	0.0802	N/A	1	---
6	11.00	13.00	0.0483	N/A	1	---
7	13.00	13.00	0.0233	N/A	1	---
8	15.00	13.00	0.0064	N/A	1	---

Sta 2+04/Sta 4+07
11.0' Wall

Design Section 3



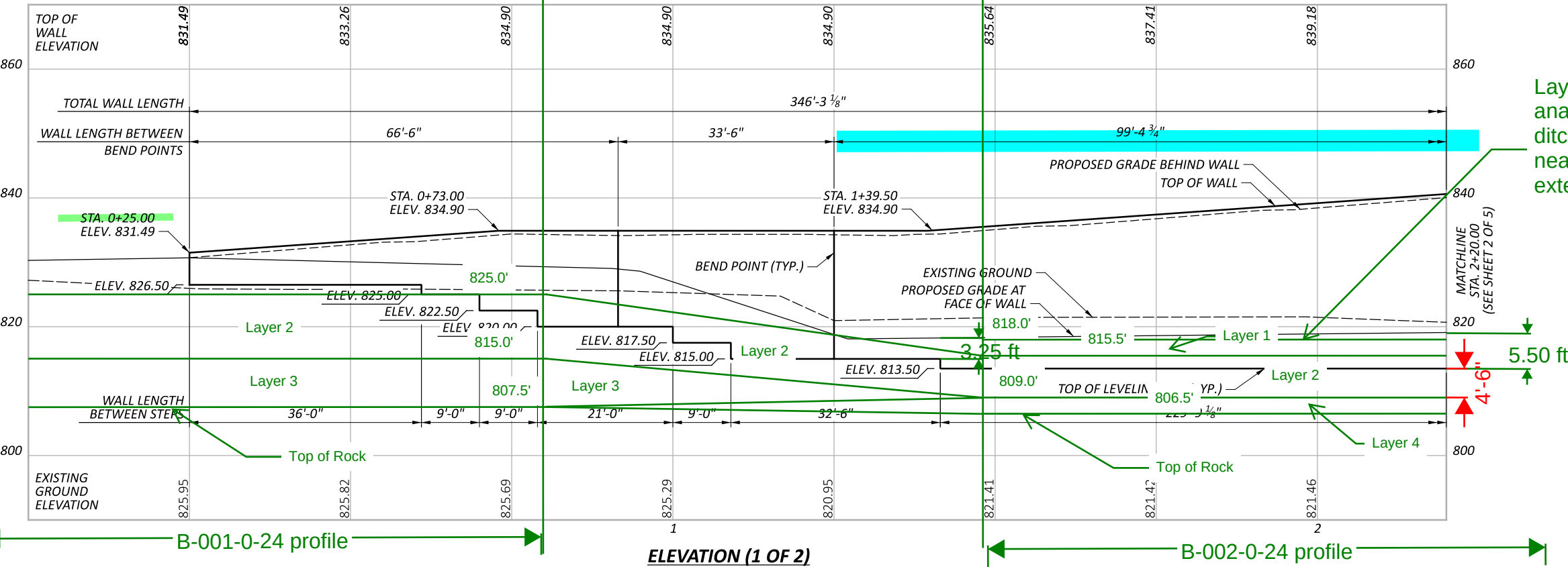
BENCHMARK DATA			
BM T14 (MAGS)	STA. 264+32.69	ELEV. 828.156	OFFSET 115.19' RT.
BM T16 (MAGS)	STA. 264+19.84	ELEV. 817.543	OFFSET 56.83' RT.

FOR ADDITIONAL BENCHMARK INFORMATION, SEE ROADWAY PLANS.

NOTES

1. EARTHWORK LIMITS SHOWN ARE APPROXIMATE. ACTUAL SLOPES SHALL CONFORM TO PLAN CROSS SECTIONS.

- MSE Wall Design Sections:
- Design Section 1
MSE Along Ramp Upslope of SR-126
 - Design Section 2 (MSE Wall at switch-back)
 - Design Section 3
MSE Wall Abutment
MSE Wall Back-to-back Ramp walls
MSE Wall Center Height Back to Back Wall
 - Design Section 4 (MSE Wall - End Wall - Full Ramp Height)

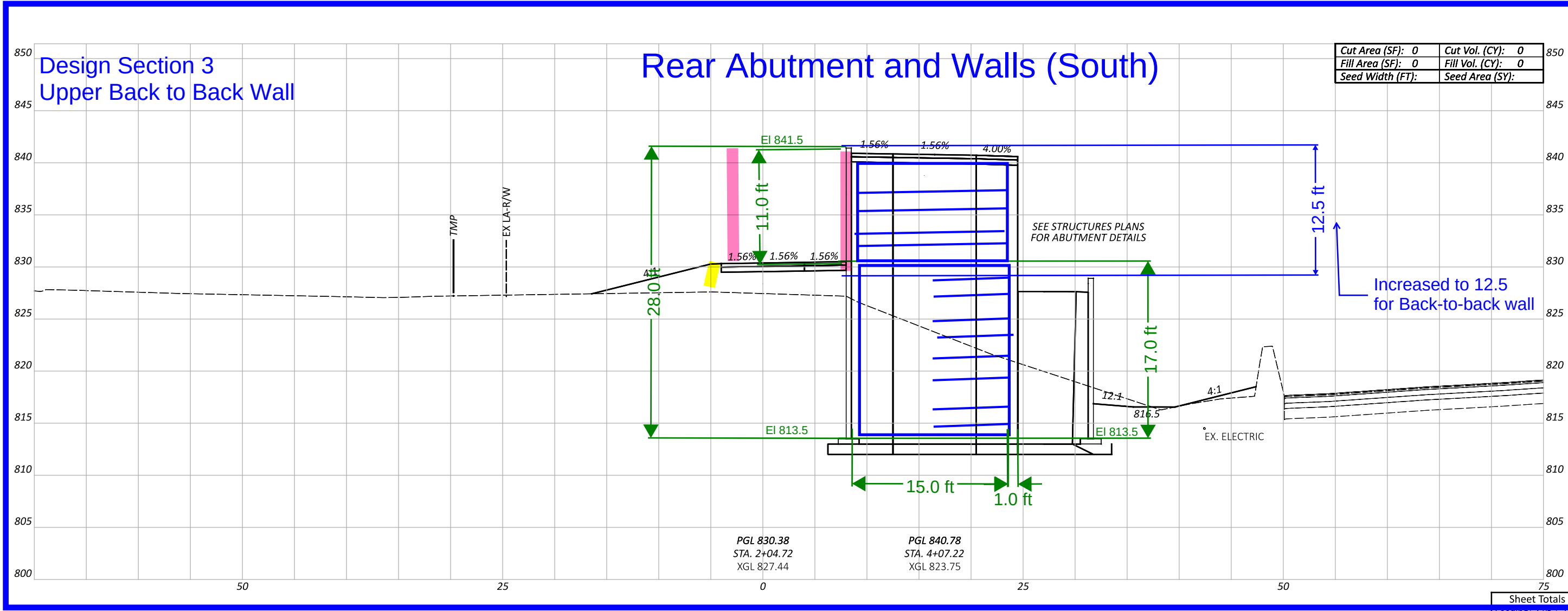


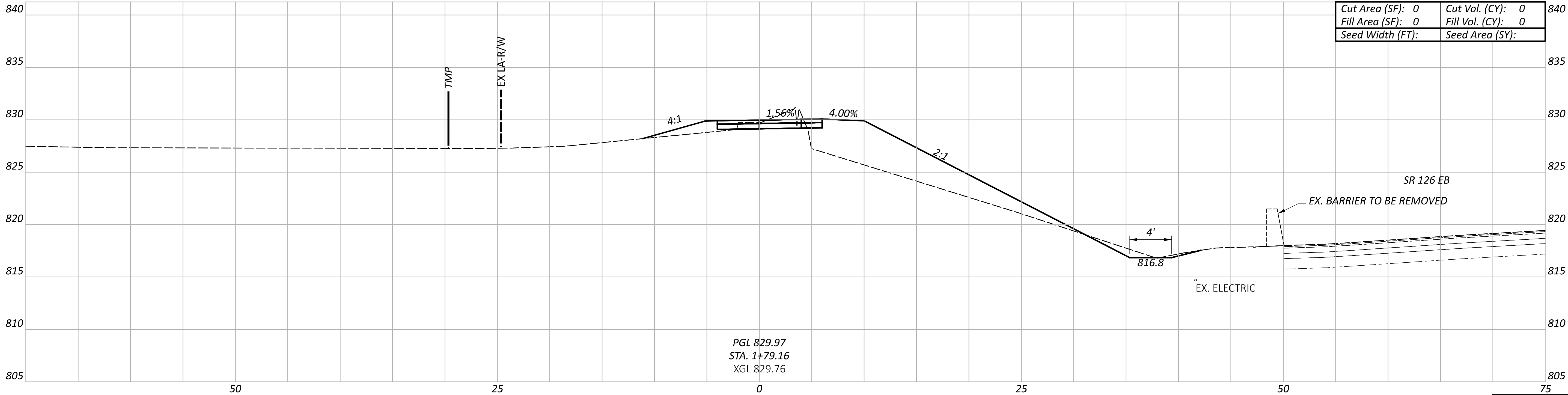
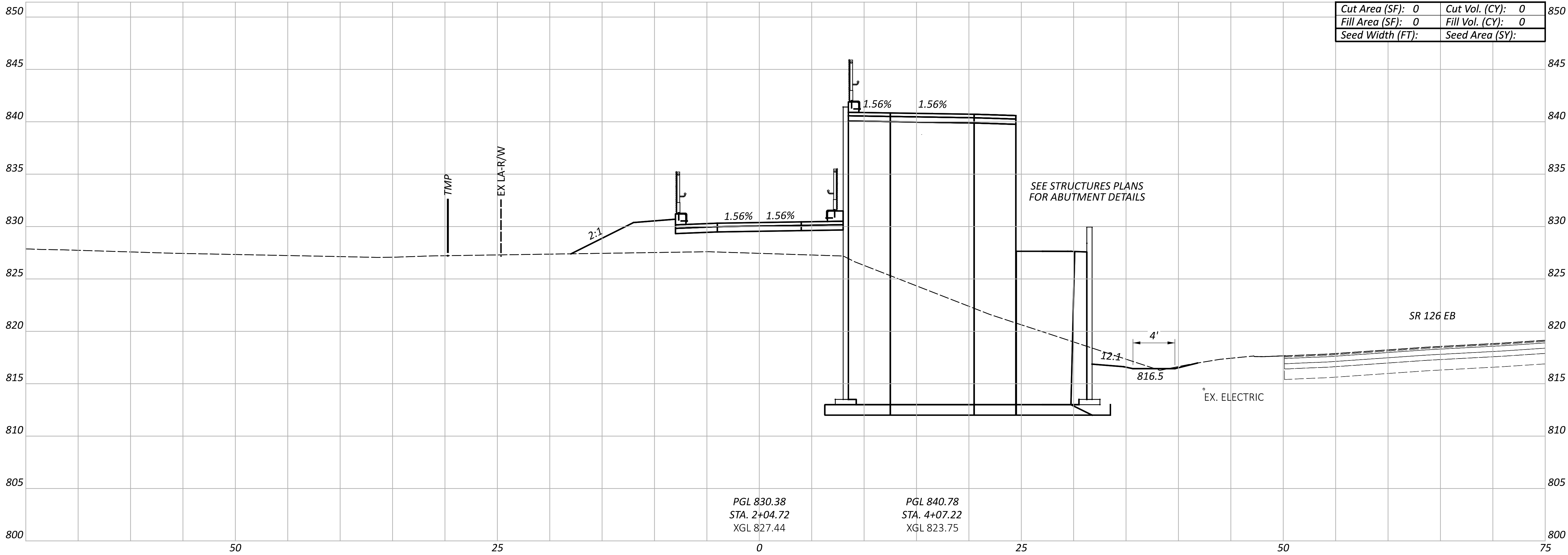
Layer 1 excluded from MSE wall analyses due to boring performed in ditch containing hydrophilic vegetation near US-126. Layer 2 assumed to extend to the existing ground surface.

WALL PLAN AND ELEVATION (1 OF 2)
WALL 001
ALONG SOUTH APPROACH

SFN	N/A
DESIGN AGENCY	HDR
9999 CARVER ROAD SUITE 210 CINCINNATI, OH 45242 513.984.7500	
DESIGNER	CHECKER
RBK	XXX
REVIEWER	
XXX MM-DD-YY	
PROJECT ID	114652
SUBSET	TOTAL
1	5
SHEET	TOTAL
P.25	32







Sheet Totals		
Seeding	Cut	Fill

CROSS SECTIONS
TA. 1+79.16, STA. 2+04.72/STA. 4+07.22

DESIGN AGENCY



DESIGNER

MJL

REVIEWER

KF 09/20/24

PROJECT ID

114652

SHEET TOTAL

P.12 32

MSEW(3.0): Update # 14.4

License number MSEW-302528

SOIL DATA

REINFORCED SOIL

Unit weight, γ	120.0 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	30.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{\text{equiv.}}$		120.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{\text{equiv.}}$		34.0°
Equivalent cohesion, $c_{\text{equiv.}}$		0.0 lb/ft ²

Water table is at wall base elevation

LATERAL EARTH PRESSURE COEFFICIENTS

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

Ka (external stability) = 0.3333 (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): $N_c = 42.16$ $N_\gamma = 41.06$

SEISMICITY

Not Applicable

License number MSEW-302528

[illegible][illegible][illegible][illegible][illegible][illegible][illegible][illegible]

AASHTO 2007-2010 (LRFD) Input Data

INTERNAL STABILITY

Load factor for vertical earth pressure, EV, from Table 3.4.1-2:	γ_{p-EV}	1.35	
Load factor for earthquake loads, EQ, from Table 3.4.1-1:	γ_{p-EQ}	1.00	
Load factor for live load surchrge, LS, from Figure C11.5.5-3(b): (Same as in External Stability).	γ_{p-LS}	1.75	
Load factor for dead load surchrge, ES: (Same as in External Stability).	γ_{p-ES}	1.50	
Resistance factor for reinforcement tension from Table 11.5.6-1: Metal Strips:	ϕ	Static 0.75	Combined static/seismic 1.00
Resistance factor for reinforcement tension in connectors from Table 11.5.6-1: Metal Strips:	ϕ	Static 0.75	Combined static/seismic 1.00
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 γ_{p-EV}	1.00	γ_{p-EQ} 1.00
Bearing Capacity γ_{p-EV}	1.35	γ_{p-EQ} 1.35
Load factor of active lateral earth pressure, EH, from Table 3.4.1-2 and Figure C11.5.5-2:	γ_{p-EH}	1.50
Load factor of active lateral earth pressure during earthquake (does not multiply P_{AE} and P_{IR}):	$(\gamma_{p-EH})_{EQ}$	1.50
Load factor for earthquake loads, EQ, from Table 3.4.1-1 (multiplies P_{AE} and P_{IR}):	γ_{p-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 = 1.31, factored bearing load = 3224 lb/ft².

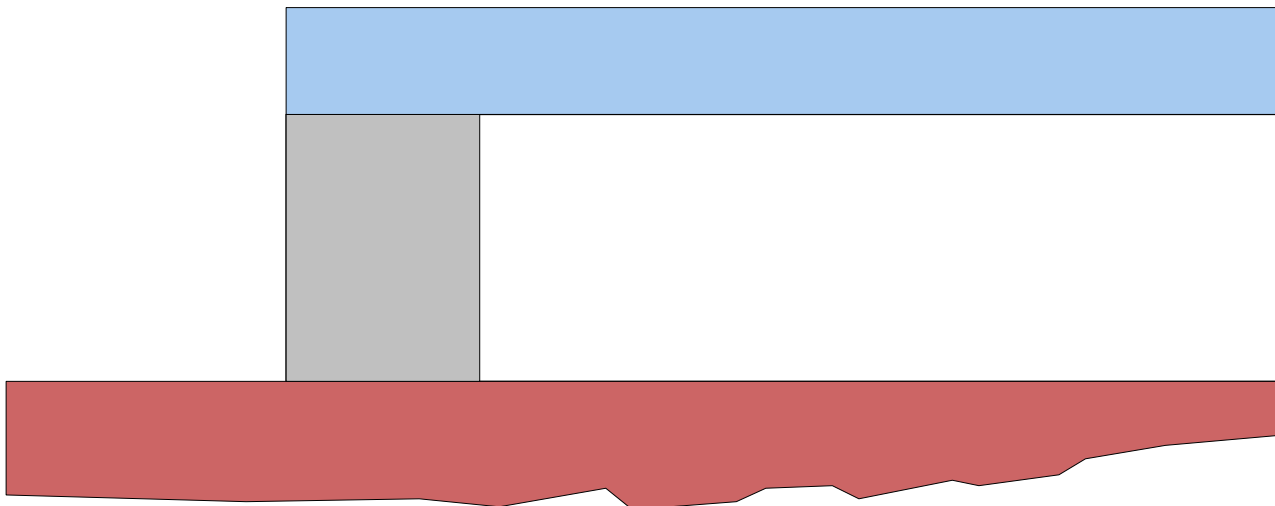
Foundation Interface: Direct sliding, CDR = 1.361, Eccentricity, $e/L = 0.2620$, CDR-overturning = 1.91

M E T A L S T R I P				C O N N E C T I O N			Metal strip strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
#	Elevation [ft]	Length [ft]	Type #	CDR [pullout resistance]	CDR [connection break]	CDR [metal strip strength]					
1	0.00	8.00	1	N/A	4.82	5.35	5.353	1.677	1.361	0.2620	---
2	2.00	8.00	1	N/A	2.64	2.93	2.930	0.705	1.557	0.1909	---
3	4.00	8.00	1	N/A	3.06	3.40	3.404	0.575	1.820	0.1303	---
4	6.00	8.00	1	N/A	3.76	4.17	4.173	0.459	2.189	0.0800	---
5	8.00	8.00	1	N/A	4.95	5.50	5.504	0.392	2.746	0.0402	---
6	10.00	8.00	1	N/A	7.39	8.22	8.215	0.209	3.683	0.0108	---

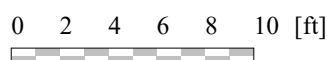
BEARING CAPACITY for GIVEN LAYOUT

	STATIC	SEISMIC	UNITS
(Water table is at wall base elevation)			
Factored bearing resistance, q-n	4230	N/A	[lb/ft ²]
Factored bearing load, σ_v	3224.3	N/A	[lb/ft ²]
Eccentricity, e	1.25	N/A	[ft]
Eccentricity, e/L	0.156	N/A	
CDR calculated	1.31	N/A	
Base length	8.00	N/A	[ft]

Unfactored applied bearing pressure = (Unfactored R) / [L - 2 * (Unfactored e)] =
Unfactored R = 12559.99 [lb/ft], L = 8.00, Unfactored e = 1.11 [ft], and Sigma = 2171.42 [lb/ft²]



SCALE:



DIRECT SLIDING for GIVEN LAYOUT (for METAL STRIPS reinforcements)

Along reinforced and foundation soils interface: CDR-static = 1.361

#	Metal strip Elevation [ft]	Metal strip Length [ft]	CDR Static	CDR Seismic	Metal strip Type #	Product name
1	0.00	8.00	1.361	N/A	1	---
2	2.00	8.00	1.557	N/A	1	---
3	4.00	8.00	1.820	N/A	1	---
4	6.00	8.00	2.189	N/A	1	---
5	8.00	8.00	2.746	N/A	1	---
6	10.00	8.00	3.683	N/A	1	---

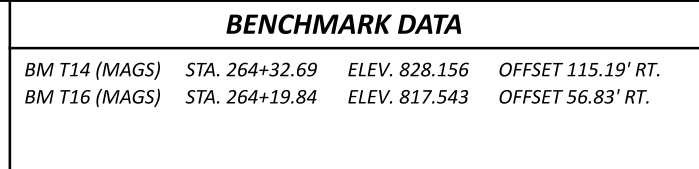
ECCENTRICITY for GIVEN LAYOUT (for Simplified Method)

At interface with foundation: e/L static = 0.2620; Overturning: CDR-static = 1.91

#	Metal strip Elevation [ft]	Metal strip Length [ft]	e / L Static	e / L Seismic	Metal strip Type #	Product name
1	0.00	8.00	0.2620	N/A	1	---
2	2.00	8.00	0.1909	N/A	1	---
3	4.00	8.00	0.1303	N/A	1	---
4	6.00	8.00	0.0800	N/A	1	---
5	8.00	8.00	0.0402	N/A	1	---
6	10.00	8.00	0.0108	N/A	1	---

Sta 2+04/Sta 4+07
28.0' Wall

Design Section 4



FOR ADDITIONAL BENCHMARK INFORMATION, SEE ROADWAY PLANS.

NOTES

1. EARTHWORK LIMITS SHOWN ARE APPROXIMATE. ACTUAL SLOPES SHALL CONFORM TO PLAN CROSS SECTIONS.

MSE Wall Design Sections:

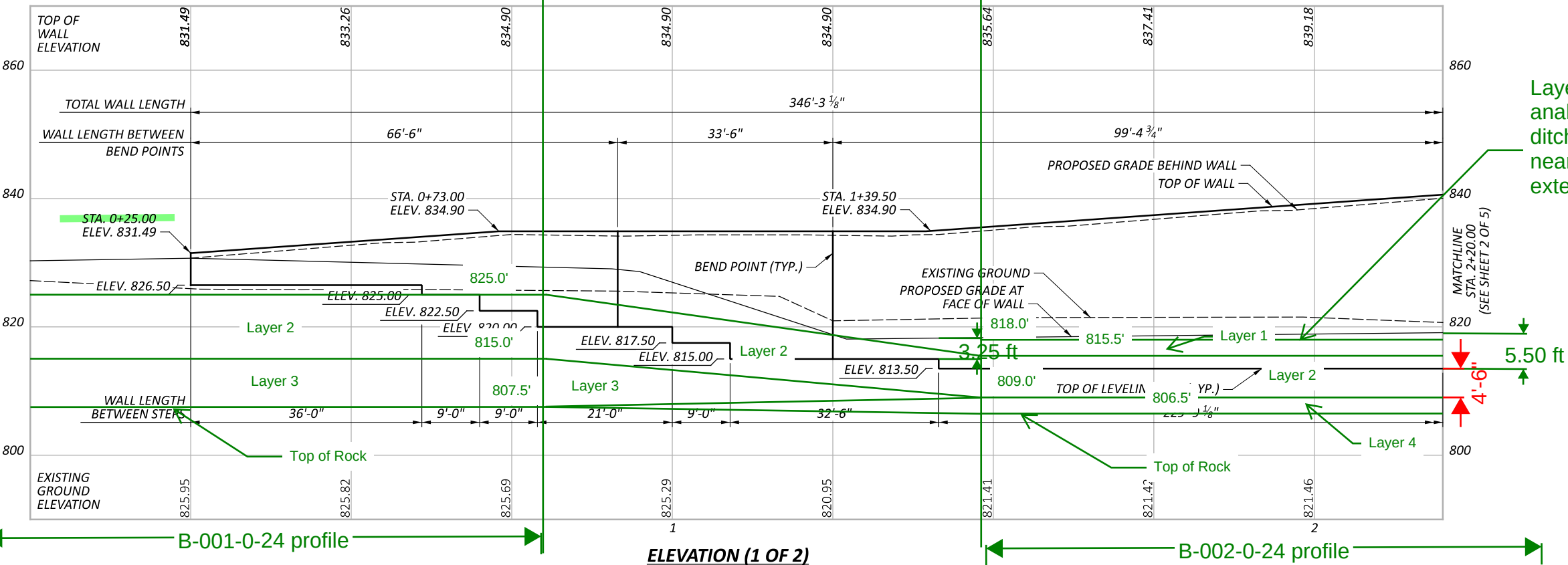
Design Section 1

MSE Along Ramp Upslope of SR-126

Design Section 2 (MSE Wall at switch-back)

Design Section 3
MSE Wall Abutment
MSE Wall Back-to-back Ramp walls
MSE Wall Center Height Back to Back Wall

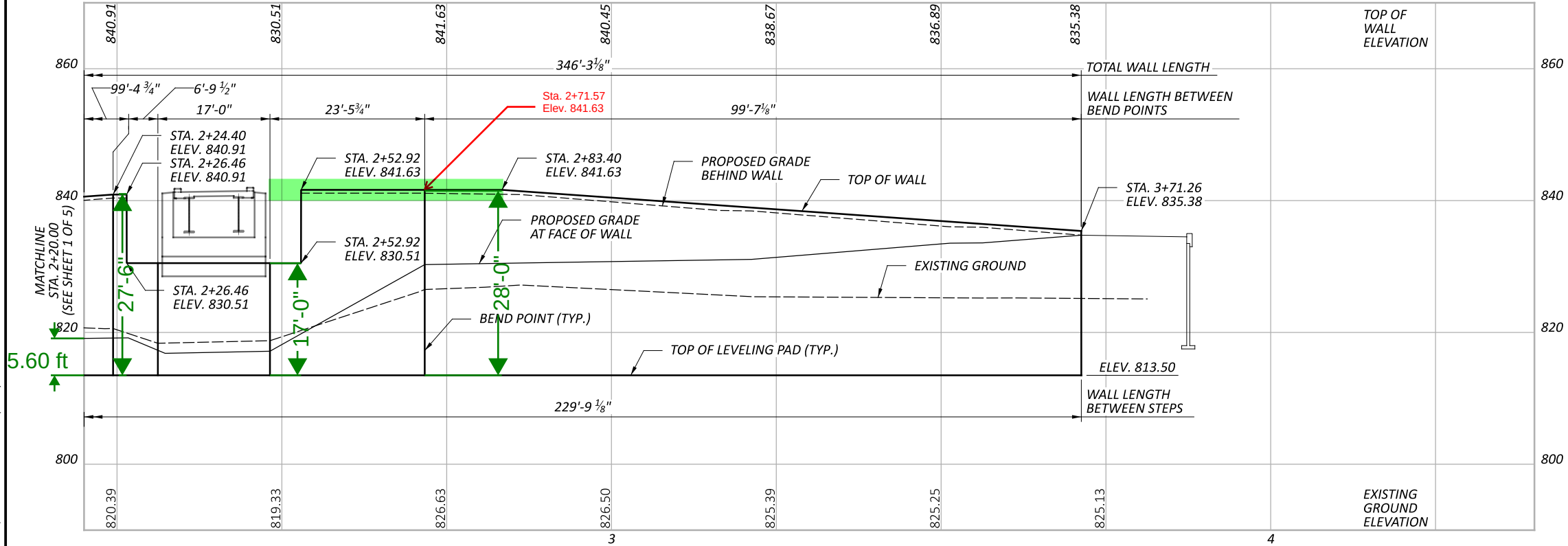
Design Section 4 (MSE Wall - End Wall - Full Ramp Height)



Layer 1 excluded from MSE wall analyses due to boring performed in ditch containing hydrophilic vegetation near US-126. Layer 2 assumed to extend to the existing ground surface.

WALL PLAN AND ELEVATION (1 OF 2)
WALL 001
ALONG SOUTH APPROACH

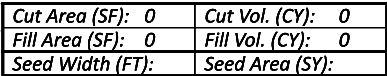
SFN	
N/A	
DESIGN AGENCY	
	
9999 CARVER ROAD SUITE 210 CINCINNATI, OH 45242 513.984.7500	
DESIGNER	CHECKER
RBK	XXX
REVIEWER	
XXX MM-DD-Y	
PROJECT ID	
114652	
SUBSET	TOTAL
1	5
SHEET	TOTAL
P.25	32



ELEVATION (2 OF 2)

WALL PLAN AND ELEVATION (2 OF 2)
WALL 001
ALONG SOUTH APPROACH

SFN		N/A	
DESIGN AGENCY			
 9999 CARVER ROAD SUITE 210 CINCINNATI, OH 45242 513.984.7500			
DESIGNER	CHECKER	REVIEWER	
RBK	XXX	XXX MM-DD-YY	
PROJECT ID			
114652			
SUBSET	TOTAL		
2	5		
SHEET	TOTAL		
P.26	32		



MSEW(3.0): Update # 14.4

License number MSEW-302528

SOIL DATA

REINFORCED SOIL

Unit weight, γ	120.0 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	34.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{\text{equiv.}}$	130.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{\text{equiv.}}$	0.0 °
Equivalent cohesion, $c_{\text{equiv.}}$	4000.0 lb/ft ²

Water table is at wall base elevation

LATERAL EARTH PRESSURE COEFFICIENTS

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

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

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): $N_c = 5.14$ $N_\gamma = 0.00$

SEISMICITY

Not Applicable

34*

- Retained is the same as Reinforced given the location of the wall at the end of two back to back MSE walls.

INPUT DATA: Metal strips
(Analysis)

D A T A	Metal strip type #1	Metal strip type #2	Metal strip type #3	Metal strip type #4	Metal strip type #5
Yield strength of steel, F_y [kips/in ²]	65.3	N/A	N/A	N/A	N/A
Gross width of strip, b [in]	2.0	N/A	N/A	N/A	N/A
Vertical spacing, S_v [ft]	Varies	N/A	N/A	N/A	N/A
Design cross section area, A_c [in ²]	0.23	N/A	N/A	N/A	N/A

Ribbed steel strips.

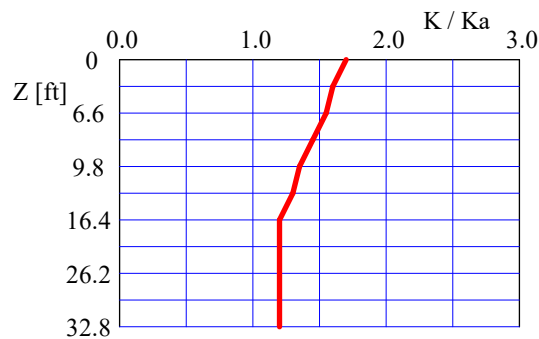
Uniformity Coefficient of reinforced soil, $C_u = D_{60}/D_{10} = 4.0$

Friction angle along reinforcement-soil interface,	ρ				
@ the top	60.97	N/A	N/A	N/A	N/A
@ 19.7 ft or below	32.00	N/A	N/A	N/A	N/A
Pullout resistance factor, F^*					
@ the top	1.80	N/A	N/A	N/A	N/A
@ 19.7 ft or below	0.62	N/A	N/A	N/A	N/A
Scale-effect correction factor, α	1.00	N/A	N/A	N/A	N/A

Note: Z for calculating K/Ka and F* is measured from roadway surface (FHWA-NHI-10-024).

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.70
3.3 ft	1.60
6.6 ft	1.55
9.8 ft	1.45
13.1 ft	1.35
16.4 ft	1.30
19.7 ft	1.20



(Analysis)

Average unit weight of panel is $\gamma_f = 152.78 \text{ lb/ft}^3$

License number MSEW-302528

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

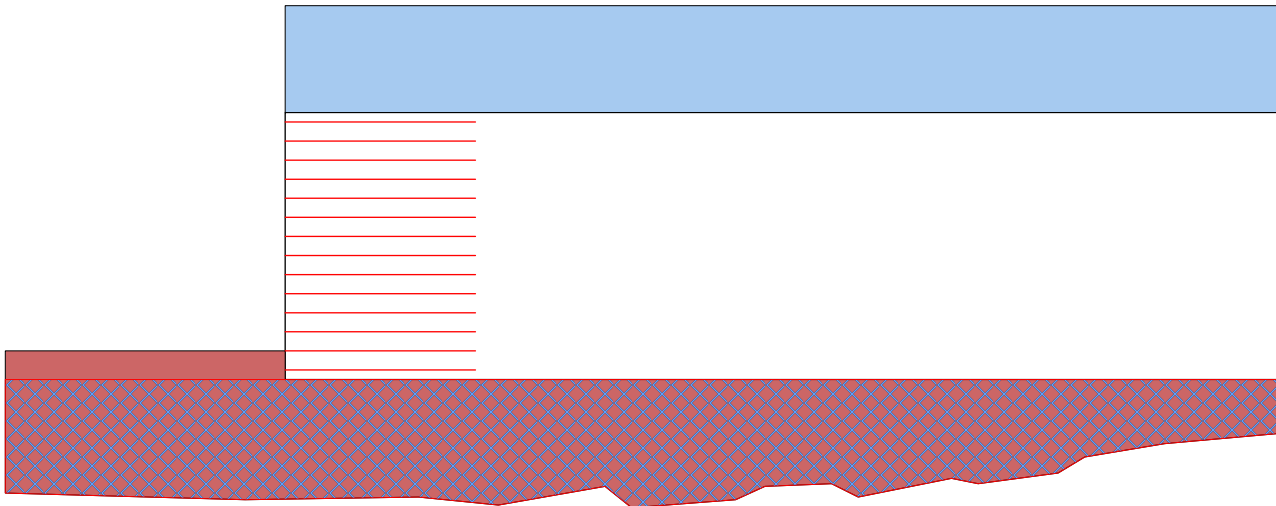
Design height, Hd	28.00	[ft]	{ Embedded depth is E = 3.00 ft, and height above top of finished bottom grade is H = 25.00 ft }
Batter, ω	0.0	[deg]	
Backslope, β	0.0	[deg]	Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)
Backslope rise	0.0	[ft]	

UNIFORM SURCHARGE

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

Hydrostatic water pressure exist in analysis. hw1 = 0.00 and hw2 = 0.00 ft.

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 8 10[ft]



ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, $CDR = 2.05$, factored bearing load = 6509 lb/ft².

Foundation Interface: Direct sliding, CDR = 1.936, Eccentricity, $e/L = 0.1746$, CDR-overturning = 2.86

METAL STRIP				CONNECTION							
#	Elevation [ft]	Length [ft]	Type #	CDR [pullout resistance]	CDR [connection break]	CDR [metal strip strength]	Metal strip strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	1.00	20.00	1	N/A	1.28	1.42	1.417	1.442	1.987	0.1636	---
2	3.00	20.00	1	N/A	1.37	1.52	1.519	1.343	2.120	0.1426	---
3	5.00	20.00	1	N/A	1.47	1.64	1.638	1.243	2.272	0.1231	---
4	7.00	20.00	1	N/A	1.60	1.78	1.776	1.144	2.448	0.1050	---
5	9.00	20.00	1	N/A	1.71	1.90	1.901	1.091	2.660	0.0883	---
6	11.00	20.00	1	N/A	1.81	2.01	2.007	1.117	2.910	0.0730	---
7	13.00	20.00	1	N/A	1.94	2.16	2.161	1.113	3.203	0.0591	---
8	15.00	20.00	1	N/A	2.13	2.37	2.367	1.138	3.562	0.0466	---
9	17.00	20.00	1	N/A	2.35	2.61	2.610	1.185	4.011	0.0356	---
10	19.00	20.00	1	N/A	2.64	2.93	2.930	1.203	4.590	0.0259	---
11	21.00	20.00	1	N/A	3.06	3.40	3.404	1.189	5.364	0.0177	---
12	23.00	20.00	1	N/A	3.76	4.17	4.173	1.132	6.452	0.0109	---
13	25.00	20.00	1	N/A	4.95	5.50	5.504	0.967	8.093	0.0055	---
14	27.00	20.00	1	N/A	7.39	8.22	8.215	0.517	10.855	0.0015	---

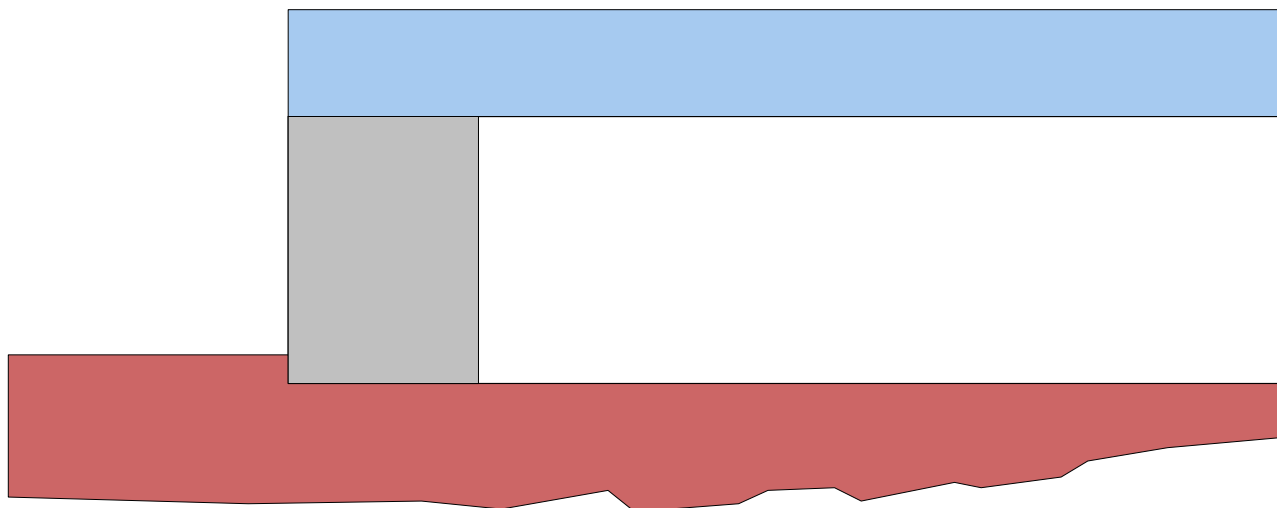
BEARING CAPACITY for GIVEN LAYOUT

	STATIC	SEISMIC	UNITS
(Water table is at wall base elevation)			
Factored bearing resistance, q_n	13368	N/A	[lb/ft ²]
Factored bearing load, σ_v	6509.1	N/A	[lb/ft ²]
Eccentricity, e	2.36	N/A	[ft]
Eccentricity, e/L	0.118	N/A	
CDR calculated	2.05	N/A	
Base length	20.00	N/A	[ft]

$$\text{Unfactored applied bearing pressure} = (\text{Unfactored } R) / [L - 2 * (\text{Unfactored } e)] =$$

Unfactored R = 72199.96 [lb/ft], L = 20.00, Unfactored e = 2.10 [ft], and Sigma = 4571.30 [lb/ft²]

0.7H (per ODOT Minimum)



SCALE:

0 2 4 6 8 10[ft]

DIRECT SLIDING for GIVEN LAYOUT (for METAL STRIPS reinforcements)

Along reinforced and foundation soils interface: CDR-static = 1.936

#	Metal strip Elevation [ft]	Metal strip Length [ft]	CDR Static	CDR Seismic	Metal strip Type #	Product name
1	1.00	20.00	1.987	N/A	1	---
2	3.00	20.00	2.120	N/A	1	---
3	5.00	20.00	2.272	N/A	1	---
4	7.00	20.00	2.448	N/A	1	---
5	9.00	20.00	2.660	N/A	1	---
6	11.00	20.00	2.910	N/A	1	---
7	13.00	20.00	3.203	N/A	1	---
8	15.00	20.00	3.562	N/A	1	---
9	17.00	20.00	4.011	N/A	1	---
10	19.00	20.00	4.590	N/A	1	---
11	21.00	20.00	5.364	N/A	1	---
12	23.00	20.00	6.452	N/A	1	---
13	25.00	20.00	8.093	N/A	1	---
14	27.00	20.00	10.855	N/A	1	---

ECCENTRICITY for GIVEN LAYOUT (for Simplified Method)

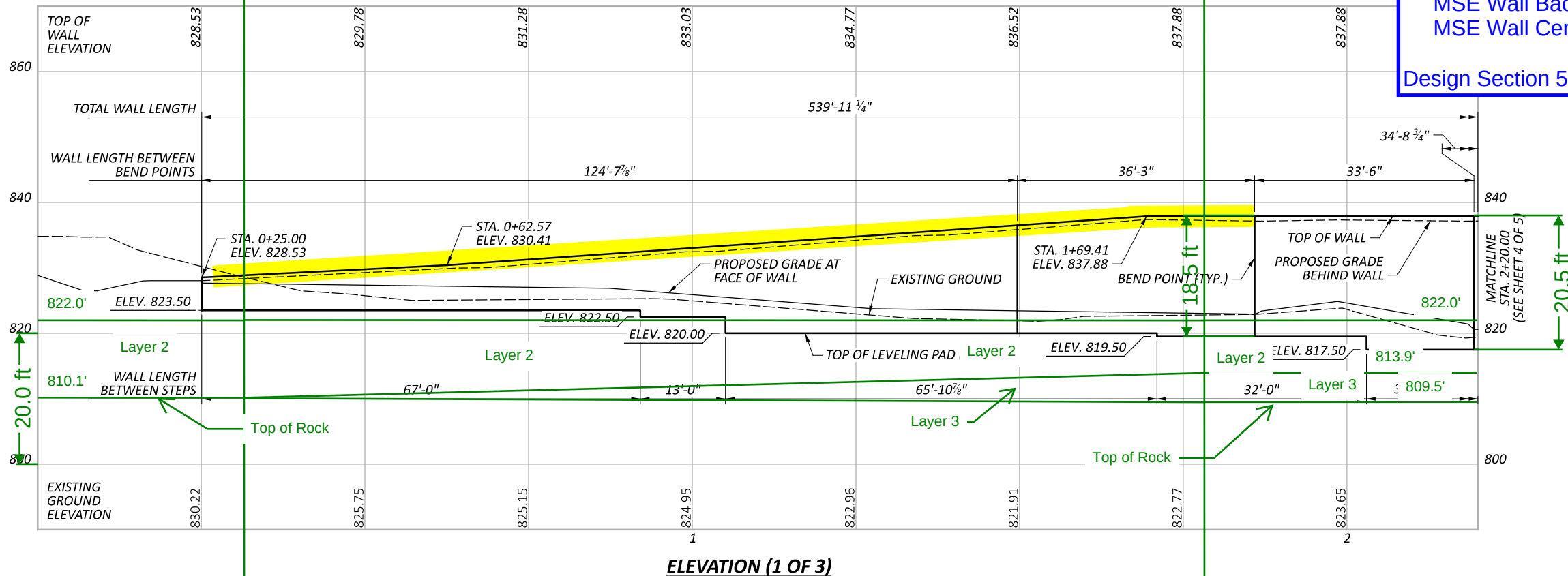
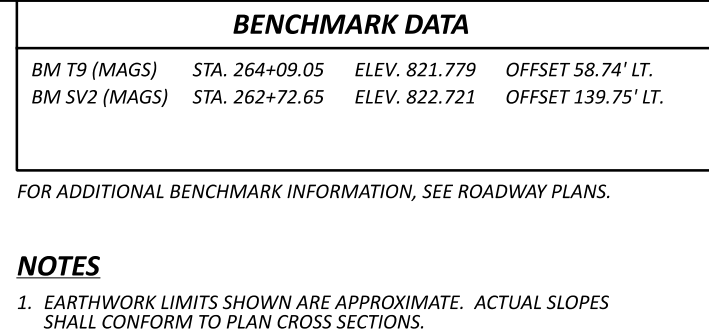
At interface with foundation: e/L static = 0.1746; Overturning: CDR-static = 2.86

#	Metal strip Elevation [ft]	Metal strip Length [ft]	e / L Static	e / L Seismic	Metal strip Type #	Product name
1	1.00	20.00	0.1636	N/A	1	---
2	3.00	20.00	0.1426	N/A	1	---
3	5.00	20.00	0.1231	N/A	1	---
4	7.00	20.00	0.1050	N/A	1	---
5	9.00	20.00	0.0883	N/A	1	---
6	11.00	20.00	0.0730	N/A	1	---
7	13.00	20.00	0.0591	N/A	1	---
8	15.00	20.00	0.0466	N/A	1	---
9	17.00	20.00	0.0356	N/A	1	---
10	19.00	20.00	0.0259	N/A	1	---
11	21.00	20.00	0.0177	N/A	1	---
12	23.00	20.00	0.0109	N/A	1	---
13	25.00	20.00	0.0055	N/A	1	---
14	27.00	20.00	0.0015	N/A	1	---

Forward Abutment (North)
Wall 002
MSEW Analyses

Sta 7+16/Sta 7+48
19.0' Wall
(Initial Ramp, Upslope of SR 126)

Design Section 1

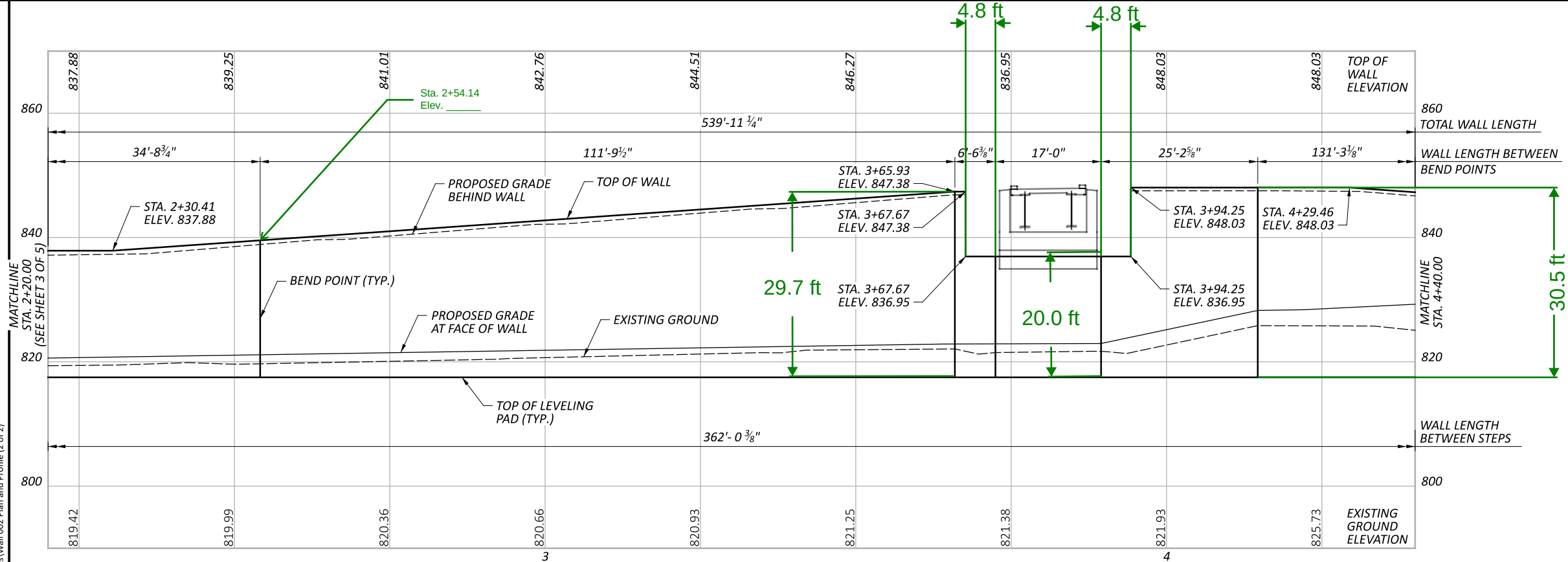


MSE Wall Design Sections:

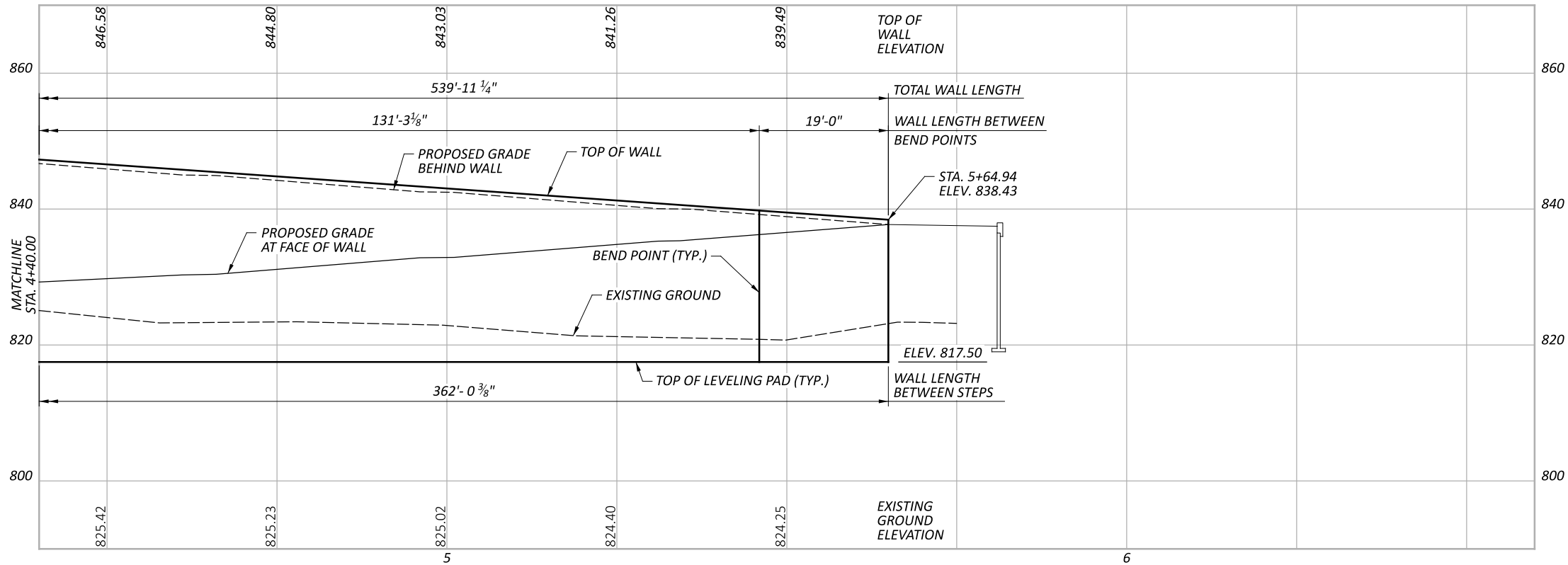
- Design Section 1
 - MSE Along Ramp Upslope of SR-126
- Design Section 2 (MSE Wall at switch-back)
- Design Section 3 Back to Back MSE Wall Upper Ramp
- Design Section 4
 - MSE Wall Abutment
 - MSE Wall Back-to-Back Ramp walls
 - MSE Wall Center Height Back to Back Wall
- Design Section 5 (MSE Wall - End Wall - Full Ramp Height)

WALL PLAN AND ELEVATION (1 OF 2)
WALL 002
ALONG NORTH APPROACH

SFN		N/A	
DESIGN AGENCY			
			
9999 CARVER ROAD SUITE 210 CINCINNATI, OH 45242 513.984.7500			
DESIGNER		CHECKER	
RBK		XXX	
REVIEWER			
XXX MM-DD-Y			
PROJECT ID			
114652			
SUBSET		TOTAL	
3		5	
SHEET		TOTAL	
P.27		32	



ELEVATION (2 OF 3)

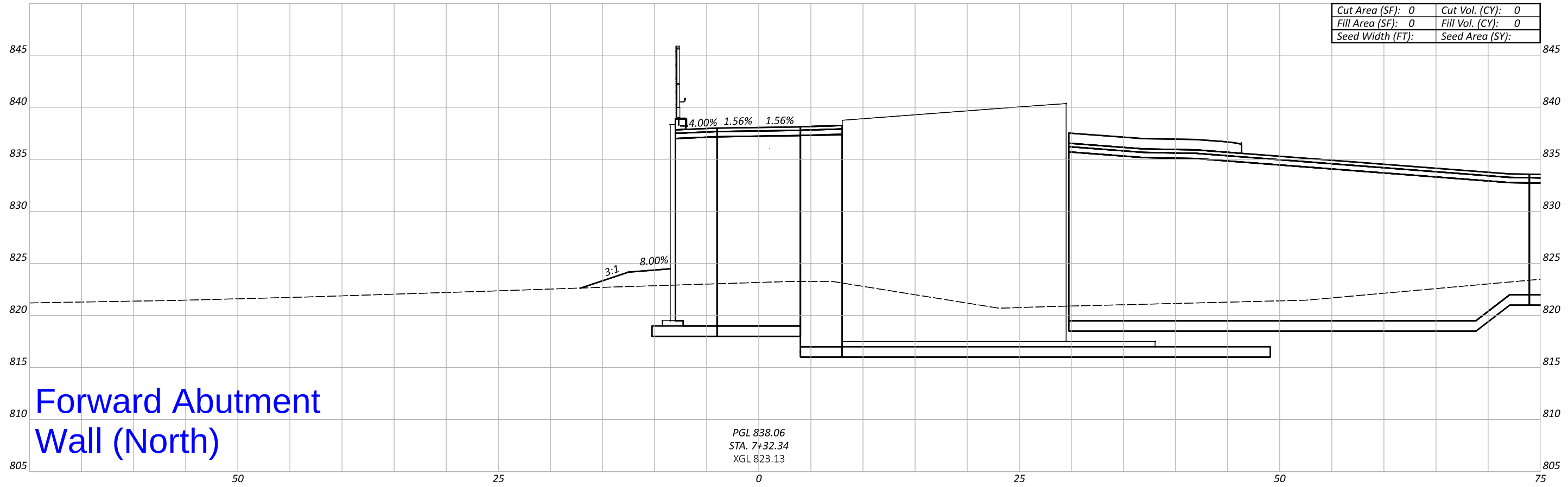


ELEVATION (3 OF 3)

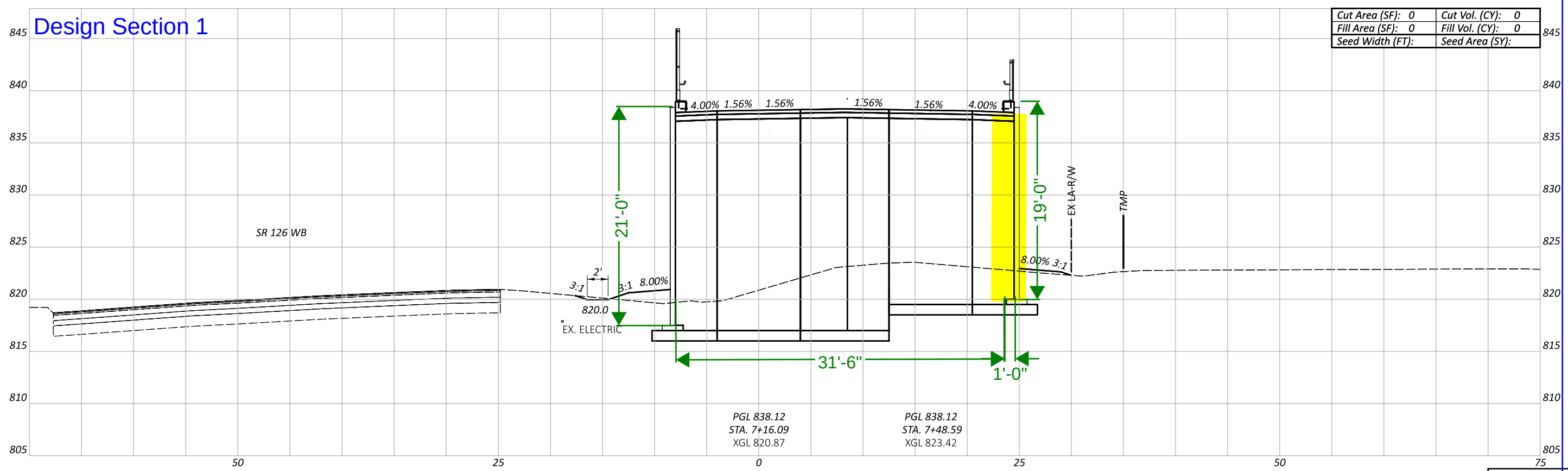
WALL PLAN AND ELEVATION (2 OF 2)
WALL 002
ALONG NORTH APPROACH

SFN	
N/A	
DESIGN AGENCY	
 9999 CARVER ROAD SUITE 210 CINCINNATI, OH 45242 513.984.7500	
DESIGNER	CHECKER
RBK	XXX
REVIEWER	
XXX MM-DD-YY	
PROJECT ID	
114652	
SUBSET	TOTAL
4	5
SHEET	TOTAL
P.28	31

Forward Abutment Wall (North)



Design Section 1



CROSS SECTIONS
STA. 7+16.09/STA. 7+48.59 AND STA. 7+32.34

DESIGN AGENCY



DESIGNER

MJL

REVIEWER

KF 09/20/24

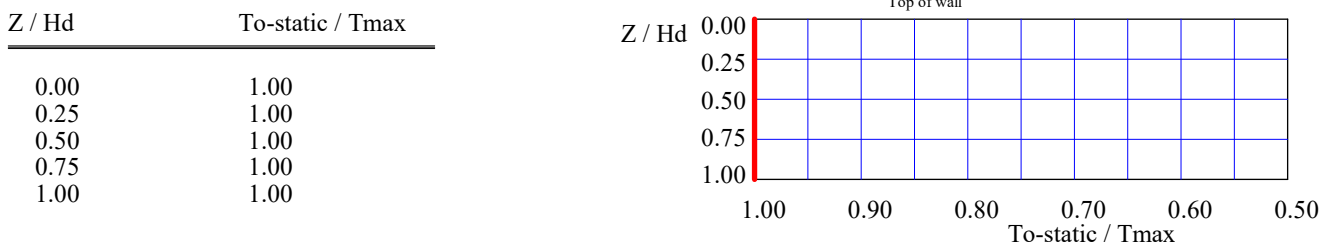
PROJECT ID

114652

Sheet Totals			SHEET	TOTAL
Seeding	Cut	Fill		
			P.22	32

INPUT DATA: Facia and Connection (Analysis)

FACIA type: Segmental precast concrete panels.
 Depth of panel is 0.50 ft. Horizontal distance to Center of Gravity of panel is 0.25 ft.
 Average unit weight of panel is $\gamma_f = 152.78 \text{ lb/ft}^3$



D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	---	N/A	N/A	N/A	N/A
Strength reduction at the connection, CRu = Fyc / Fy	0.90	N/A	N/A	N/A	N/A

MSEW -- Mechanically Stabilized Earth Walls

Present Date/Time: Tue Jun 17 09:12:52 2025

C:\Users\HPATEL\Documents\MSEW_Darren\20250606_HAM-126-19.50_NorthAbutment_Sta716-748_19.0'wall.BE

MSEW -- Mechanically Stabilized Earth Walls

Present Date/Time: Tue Jun 17 09:12:52 2025

C:\Users\HPATEL\Documents\MSEW_Darren\20250606_HAM-126-19.50_NorthAbutment_Sta716-748_19.0'wall.BE

MSEW -- Mechanically Stabilized Earth Walls

Present Date/Time: Tue Jun 17 09:12:52 2025

C:\Users\HPATEL\Documents\MSEW_Darren\20250606_HAM-126-19.50_NorthAbutment_Sta716-748_19.0'wall.BE

MSEW -- Mechanically Stabilized Earth Walls

Present Date/Time: Tue Jun 17 09:12:52 2025

C:\Users\HPATEL\Documents\MSEW_Darren\20250606_HAM-126-19.50_NorthAbutment_Sta716-748_19.0'wall.BE

MSEW -- Mechanically Stabilized Earth Walls

Present Date/Time: Tue Jun 17 09:12:52 2025

C:\Users\HPATEL\Documents\MSEW_Darren\20250606_HAM-126-19.50_NorthAbutment_Sta716-748_19.0'wall.BE

MSEW -- Mechanically Stabilized Earth Walls

Present Date/Time: Tue Jun 17 09:12:52 2025

C:\Users\HPATEL\Documents\MSEW_Darren\20250606_HAM-126-19.50_NorthAbutment_Sta716-748_19.0'wall.BE



MSEW -- Mechanically Stabilized Earth Walls

Present Date/Time: Tue Jun 17 09:12:52 2025

C:\Users\HPATEL\Documents\MSEW_Darren\20250606_HAM-126-19.50_NorthAbutment_Sta716-748_19.0'wall.BE

MSEW -- Mechanically Stabilized Earth Walls

Present Date/Time: Tue Jun 17 09:12:52 2025

C:\Users\HPATEL\Documents\MSEW_Darren\20250606_HAM-126-19.50_NorthAbutment_Sta716-748_19.0'wall.BE



ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, $CDR = 1.65$, factored bearing load = 4852 lb/ft².

Foundation Interface: Direct sliding, CDR = 1.583, Eccentricity, $e/L = 0.2124$, CDR-overtopping = 2.35

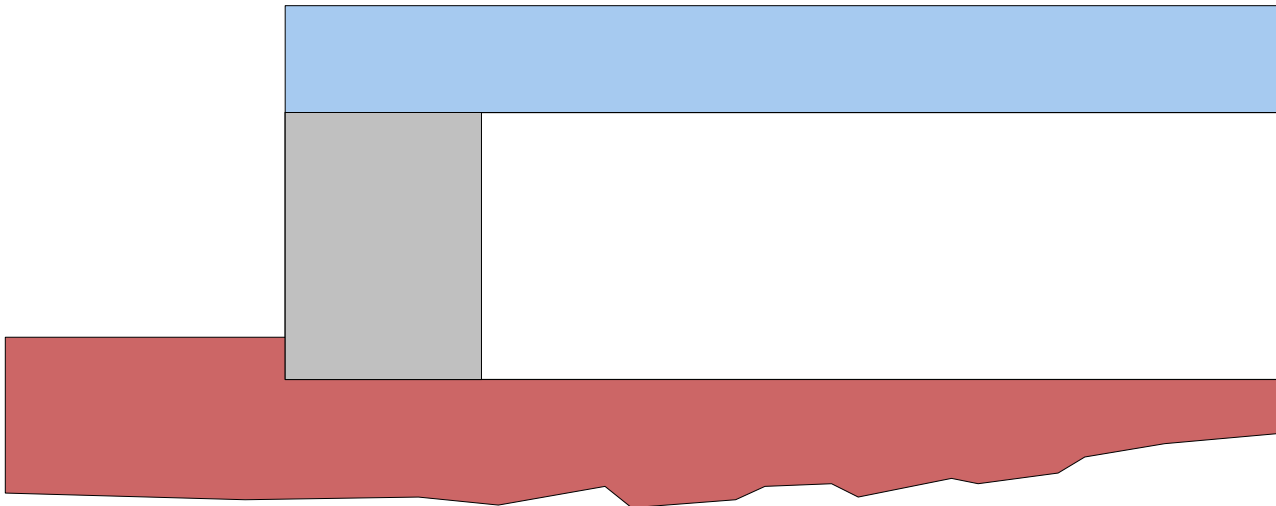
M E T A L S T R I P				C O N N E C T I O N							
#	Elevation [ft]	Length [ft]	Type #	CDR [pullout resistance]	CDR [connection break]	CDR [metal strip strength]	Metal strip strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.95	14.00	1	N/A	1.85	2.05	2.052	1.118	1.649	0.1945	---
2	2.85	14.00	1	N/A	1.96	2.17	2.173	1.122	1.798	0.1610	---
3	4.75	14.00	1	N/A	2.12	2.35	2.355	1.105	1.976	0.1305	---
4	6.65	14.00	1	N/A	2.32	2.57	2.572	1.052	2.195	0.1031	---
5	8.55	14.00	1	N/A	2.55	2.83	2.828	0.960	2.467	0.0788	---
6	10.45	14.00	1	N/A	2.86	3.18	3.178	0.905	2.817	0.0576	---
7	12.35	14.00	1	N/A	3.33	3.70	3.696	0.891	3.281	0.0394	---
8	14.25	14.00	1	N/A	4.08	4.53	4.528	0.843	3.930	0.0243	---
9	16.15	14.00	1	N/A	5.34	5.94	5.939	0.713	4.898	0.0123	---
10	18.05	14.00	1	N/A	7.88	8.75	8.754	0.375	6.500	0.0033	---

BEARING CAPACITY for GIVEN LAYOUT

	STATIC	SEISMIC	UNITS
(Water table is at wall base elevation)			
Factored bearing resistance, q-n	8021	N/A	[lb/ft ²]
Factored bearing load, σ_v	4852.3	N/A	[lb/ft ²]
Eccentricity, e	1.93	N/A	[ft]
Eccentricity, e/L	0.138	N/A	
CDR calculated	1.65	N/A	
Base length	14.00	N/A	[ft]

$$\text{Unfactored applied bearing pressure} = (\text{Unfactored R}) / [L - 2 * (\text{Unfactored e})] =$$

Unfactored $R = 35419.98$ [lb/ft], $L = 14.00$, Unfactored $e = 1.72$ [ft], and $\text{Sigma} = 3351.41$ [lb/ft²]



SCALE:

0 2 4 6 8 10 [ft]



DIRECT SLIDING for GIVEN LAYOUT (for METAL STRIPS reinforcements)

Along reinforced and foundation soils interface: CDR-static = 1.583

#	Metal strip Elevation [ft]	Metal strip Length [ft]	CDR Static	CDR Seismic	Metal strip Type #	Product name
1	0.95	14.00	1.649	N/A	1	---
2	2.85	14.00	1.798	N/A	1	---
3	4.75	14.00	1.976	N/A	1	---
4	6.65	14.00	2.195	N/A	1	---
5	8.55	14.00	2.467	N/A	1	---
6	10.45	14.00	2.817	N/A	1	---
7	12.35	14.00	3.281	N/A	1	---
8	14.25	14.00	3.930	N/A	1	---
9	16.15	14.00	4.898	N/A	1	---
10	18.05	14.00	6.500	N/A	1	---

ECCENTRICITY for GIVEN LAYOUT (for Simplified Method)

At interface with foundation: e/L static = 0.2124; Overturning: CDR-static = 2.35

#	Metal strip Elevation [ft]	Metal strip Length [ft]	e / L Static	e / L Seismic	Metal strip Type #	Product name
1	0.95	14.00	0.1945	N/A	1	---
2	2.85	14.00	0.1610	N/A	1	---
3	4.75	14.00	0.1305	N/A	1	---
4	6.65	14.00	0.1031	N/A	1	---
5	8.55	14.00	0.0788	N/A	1	---
6	10.45	14.00	0.0576	N/A	1	---
7	12.35	14.00	0.0394	N/A	1	---
8	14.25	14.00	0.0243	N/A	1	---
9	16.15	14.00	0.0123	N/A	1	---
10	18.05	14.00	0.0033	N/A	1	---

Sta 7+16/Sta 7+48
21.0' Wall

Design Section 2



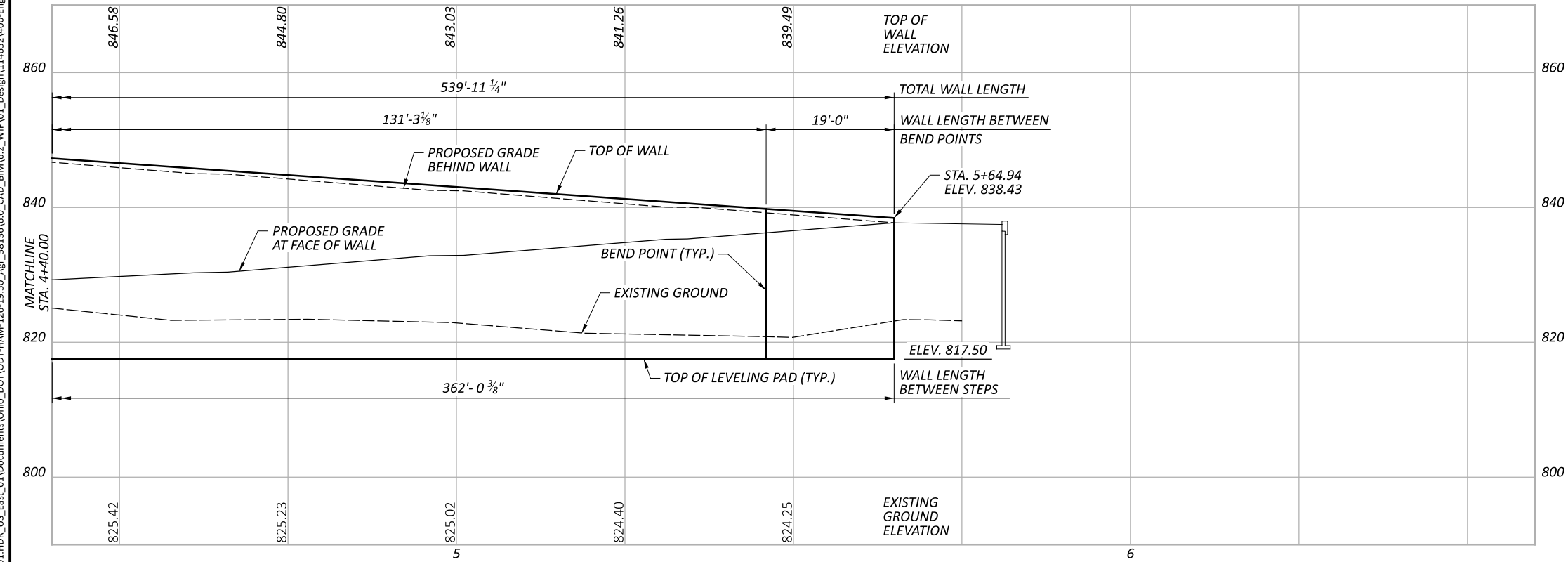
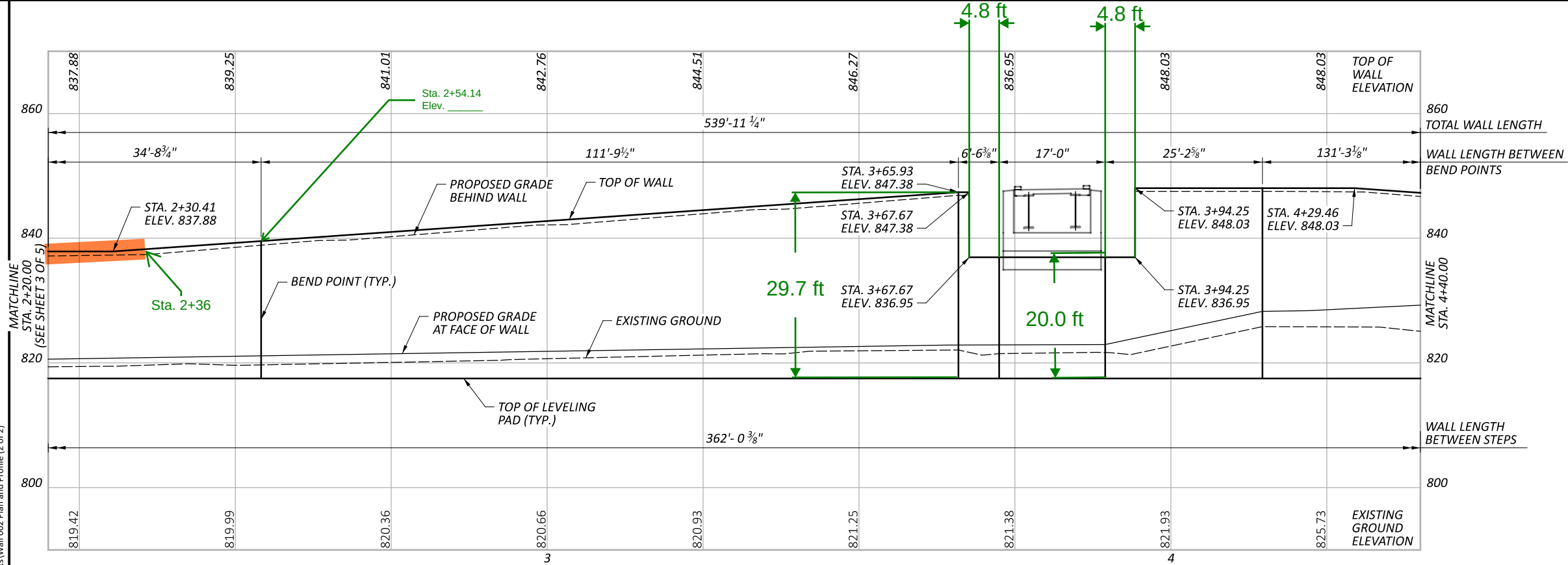
FOR ADDITIONAL BENCHMARK INFORMATION, SEE ROADWAY PLANS.

1. EARTHWORK LIMITS SHOWN ARE APPROXIMATE. ACTUAL SLOPES SHALL CONFORM TO PLAN CROSS SECTIONS.

Design Section 5 (MSE Wall - End Wall - Full Ramp Height)

WALL PLAN AND ELEVATION (1 OF 2)
WALL 002
ALONG NORTH APPROACH

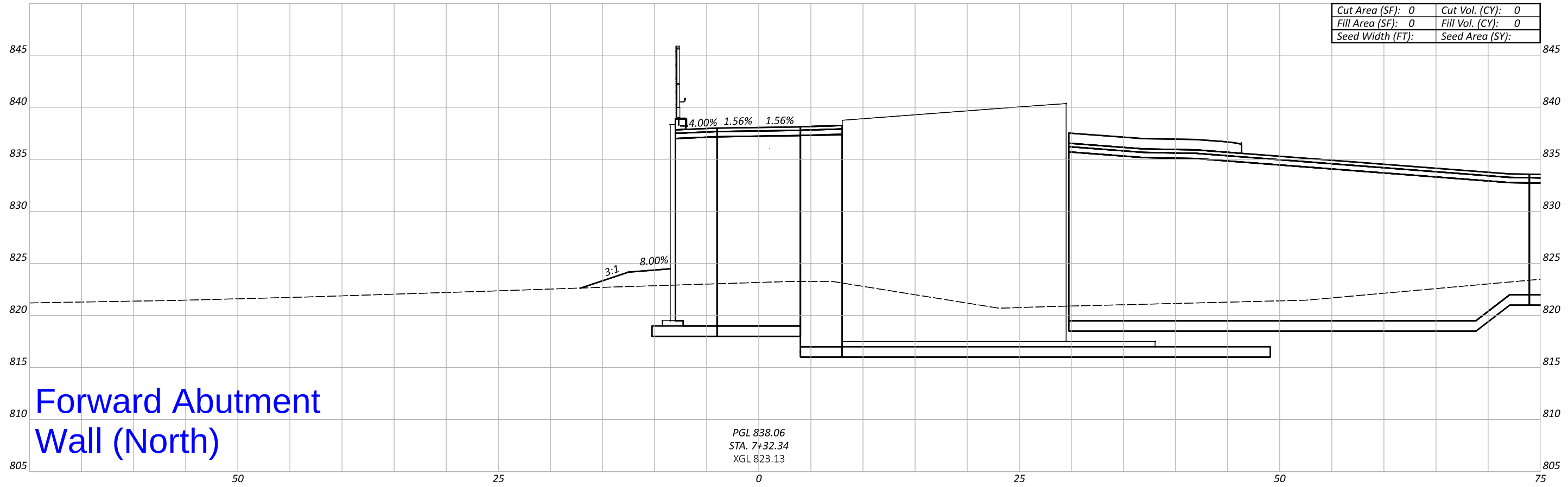
SFN		N/A	
DESIGN AGENCY			
			
9999 CARVER ROAD SUITE 210 CINCINNATI, OH 45242 513.984.7500			
DESIGNER		CHECKER	
RBK		XXX	
REVIEWER			
XXX MM-DD-Y			
PROJECT ID			
114652			
SUBSET		TOTAL	
3		5	
SHEET		TOTAL	
P.27		32	



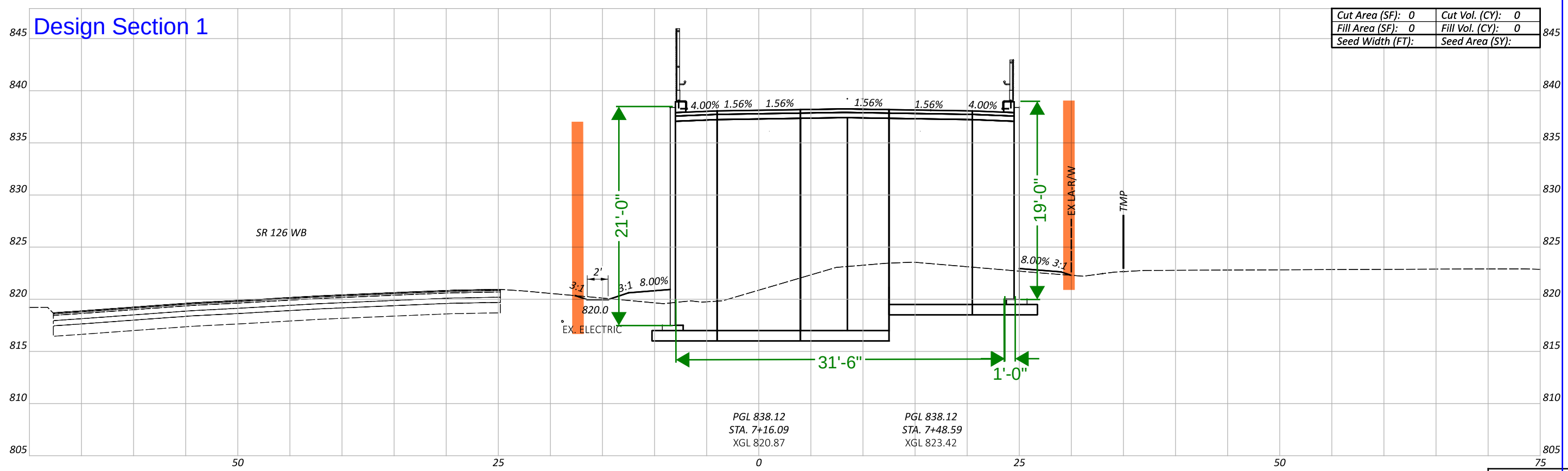
WALL PLAN AND ELEVATION (2 OF 2)
WALL 002
ALONG NORTH APPROACH

SFN	
N/A	
DESIGN AGENCY	
	
9999 CARVER ROAD SUITE 210 CINCINNATI, OH 45242 513.984.7500	
DESIGNER	CHECKER
RBK	XXX
REVIEWER	
XXX MM-DD-YY	
PROJECT ID	
114652	
SUBSET	TOTAL
4	5
SHEET	TOTAL
P.28	31

Forward Abutment Wall (North)



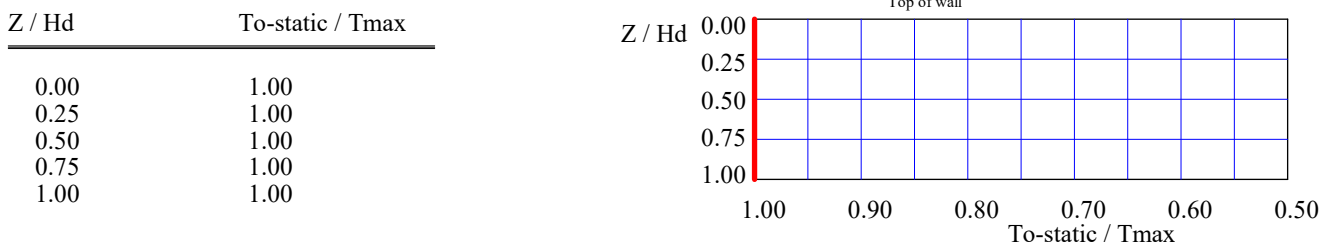
Design Section 1



CROSS SECTIONS
STA. 7+16.09/STA. 7+48.59 AND STA. 7+32.34

INPUT DATA: Facia and Connection (Analysis)

FACIA type: Segmental precast concrete panels.
 Depth of panel is 0.50 ft. Horizontal distance to Center of Gravity of panel is 0.25 ft.
 Average unit weight of panel is $\gamma_f = 152.78 \text{ lb/ft}^3$



D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	---	N/A	N/A	N/A	N/A
Strength reduction at the connection, CRu = Fyc / Fy	0.90	N/A	N/A	N/A	N/A

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

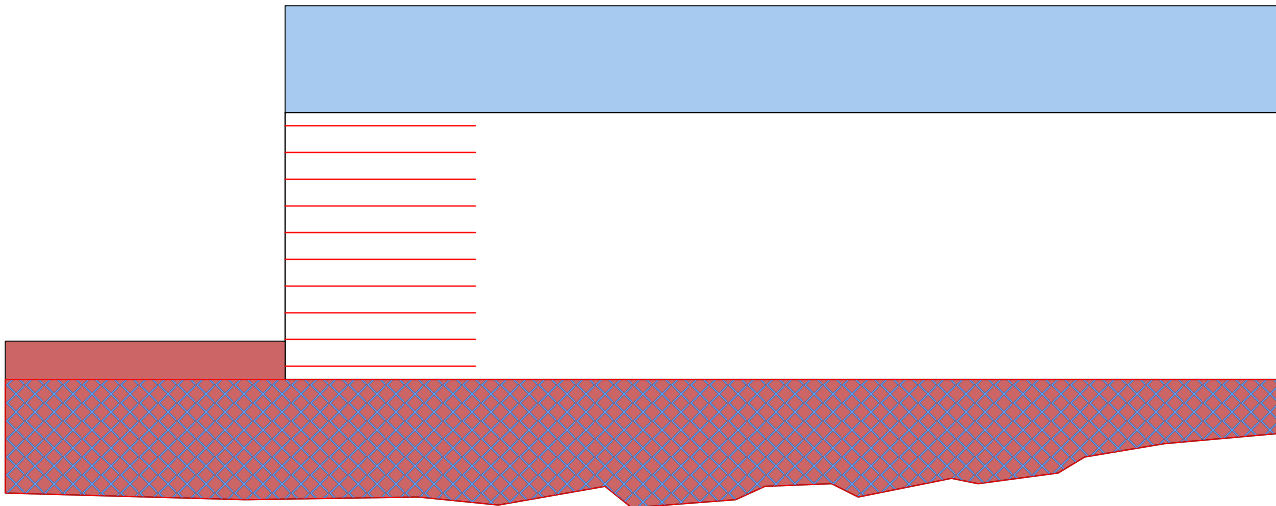
Design height, Hd	21.00	[ft]	{ Embedded depth is E = 3.00 ft, and height above top of finished bottom grade is H = 18.00 ft }
Batter, ω	0.0	[deg]	
Backslope, β	0.0	[deg]	Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)
Backslope rise	0.0	[ft]	

UNIFORM SURCHARGE

Uniformly distributed dead load is 0.0 [lb/ft²], and live load is 250.0 [lb/ft²]

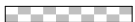
Hydrostatic water pressure exist in analysis. hw1 = 0.00 and hw2 = 0.00 ft.

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:	γ_{p-EV}	1.35	
Load factor for earthquake loads, EQ, from Table 3.4.1-1:	γ_{p-EQ}	1.00	
Load factor for live load surchrge, LS, from Figure C11.5.5-3(b): (Same as in External Stability).	γ_{p-LS}	1.75	
Load factor for dead load surchrge, ES: (Same as in External Stability).	γ_{p-ES}	1.50	
Resistance factor for reinforcement tension from Table 11.5.6-1: Metal Strips:	ϕ	Static 0.75	Combined static/seismic 1.00
Resistance factor for reinforcement tension in connectors from Table 11.5.6-1: Metal Strips:	ϕ	Static 0.75	Combined static/seismic 1.00
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 γ_{p-EV}	1.00	γ_{p-EQ} 1.00
Bearing Capacity γ_{p-EV}	1.35	γ_{p-EQ} 1.35
Load factor of active lateral earth pressure, EH, from Table 3.4.1-2 and Figure C11.5.5-2:	γ_{p-EH}	1.50
Load factor of active lateral earth pressure during earthquake (does not multiply P_{AE} and P_{IR}):	$(\gamma_{p-EH})_{EQ}$	1.50
Load factor for earthquake loads, EQ, from Table 3.4.1-1 (multiplies P_{AE} and P_{IR}):	γ_{p-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, $CDR = 1.58$, factored bearing load = 5085 lb/ft².

Foundation Interface: Direct sliding, CDR = 1.845, Eccentricity, $e/L = 0.1866$, CDR-overturning = 2.68

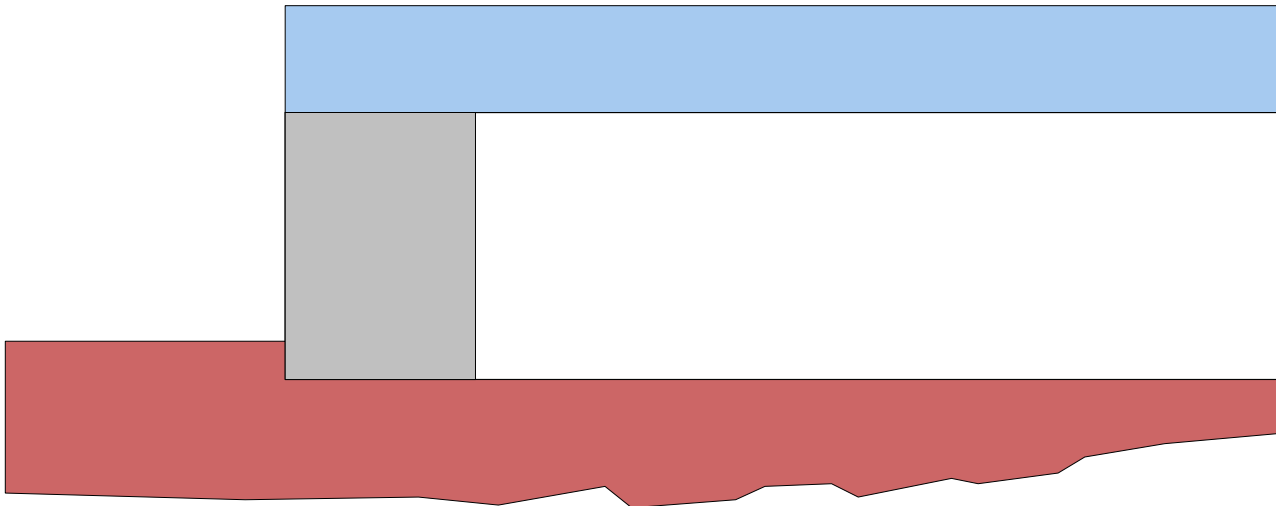
METAL STRIP				CONNECTION							Product name
#	Elevation [ft]	Length [ft]	Type #	CDR [pullout resistance]	CDR [connection break]	CDR [metal strip strength]	Metal strip strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	
1	1.05	15.00	1	N/A	1.58	1.75	1.753	0.976	1.914	0.1707	---
2	3.15	15.00	1	N/A	1.68	1.87	1.866	0.997	2.101	0.1410	---
3	5.25	15.00	1	N/A	1.80	2.00	1.996	0.997	2.315	0.1140	---
4	7.35	15.00	1	N/A	1.97	2.19	2.188	0.970	2.578	0.0898	---
5	9.45	15.00	1	N/A	2.18	2.42	2.419	0.901	2.908	0.0684	---
6	11.55	15.00	1	N/A	2.44	2.71	2.713	0.858	3.334	0.0497	---
7	13.65	15.00	1	N/A	2.83	3.15	3.147	0.853	3.908	0.0338	---
8	15.75	15.00	1	N/A	3.47	3.86	3.859	0.816	4.719	0.0207	---
9	17.85	15.00	1	N/A	4.61	5.12	5.118	0.704	5.956	0.0103	---
10	19.95	15.00	1	N/A	6.96	7.73	7.730	0.382	8.072	0.0028	---

BEARING CAPACITY for GIVEN LAYOUT

	STATIC	SEISMIC	UNITS
(Water table is at wall base elevation)			
Factored bearing resistance, q-n	8021	N/A	[lb/ft ²]
Factored bearing load, σ_v	5085.3	N/A	[lb/ft ²]
Eccentricity, e	1.84	N/A	[ft]
Eccentricity, e/L	0.122	N/A	
CDR calculated	1.58	N/A	
Base length	15.00	N/A	[ft]

$$\text{Unfactored applied bearing pressure} = (\text{Unfactored R}) / [L - 2 * (\text{Unfactored e})] =$$

Unfactored $R = 41549.97$ [lb/ft], $L = 15.00$, Unfactored $e = 1.64$ [ft], and **Sigma = 3542.41** [lb/ft²]



SCALE:

0 2 4 6 8 10[ft]



DIRECT SLIDING for GIVEN LAYOUT (for METAL STRIPS reinforcements)

Along reinforced and foundation soils interface: CDR-static = 1.845

#	Metal strip Elevation [ft]	Metal strip Length [ft]	CDR Static	CDR Seismic	Metal strip Type #	Product name
1	1.05	15.00	1.914	N/A	1	---
2	3.15	15.00	2.101	N/A	1	---
3	5.25	15.00	2.315	N/A	1	---
4	7.35	15.00	2.578	N/A	1	---
5	9.45	15.00	2.908	N/A	1	---
6	11.55	15.00	3.334	N/A	1	---
7	13.65	15.00	3.908	N/A	1	---
8	15.75	15.00	4.719	N/A	1	---
9	17.85	15.00	5.956	N/A	1	---
10	19.95	15.00	8.072	N/A	1	---

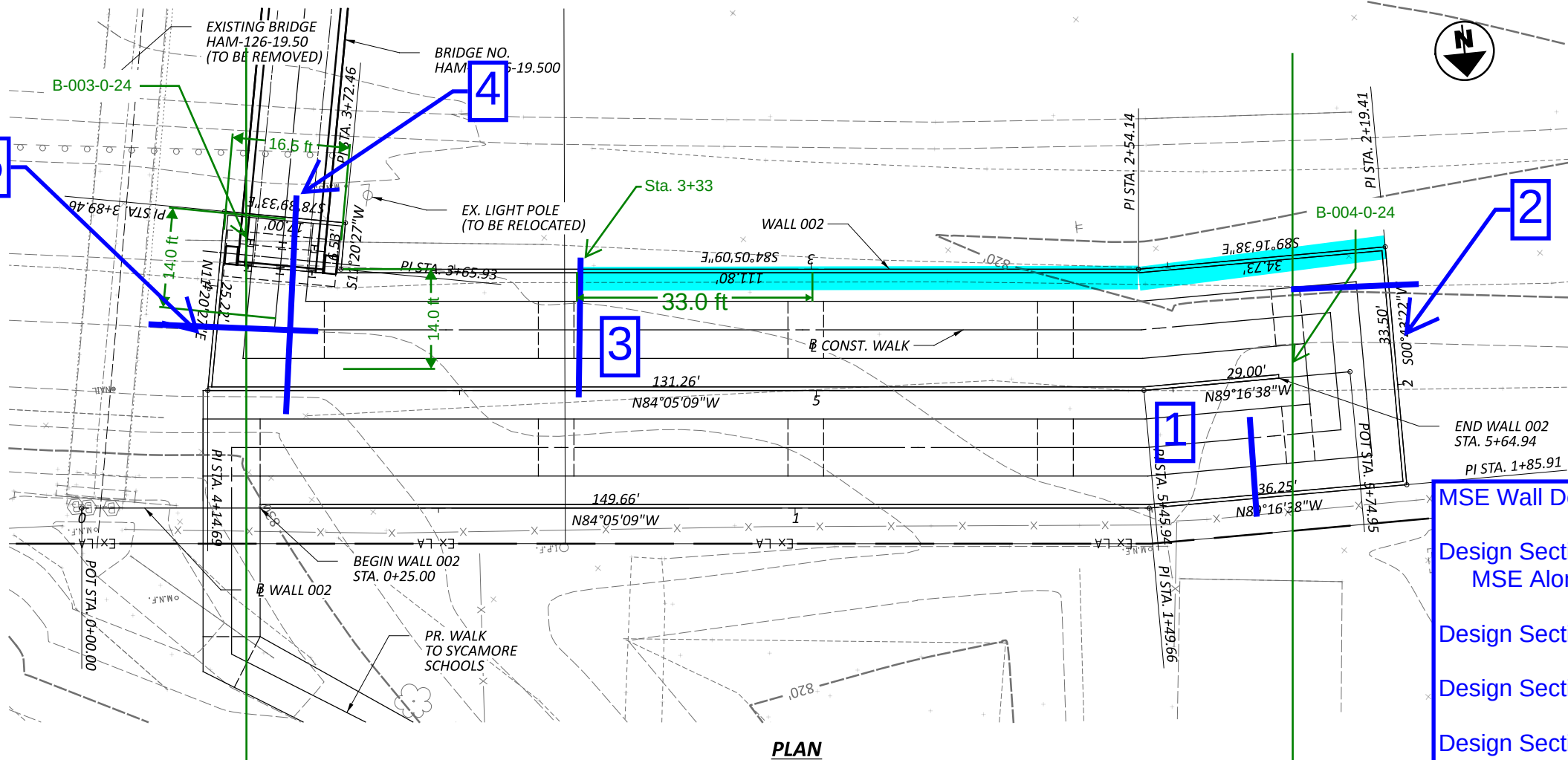
ECCENTRICITY for GIVEN LAYOUT (for Simplified Method)

At interface with foundation: e/L static = 0.1866; Overturning: CDR-static = 2.68

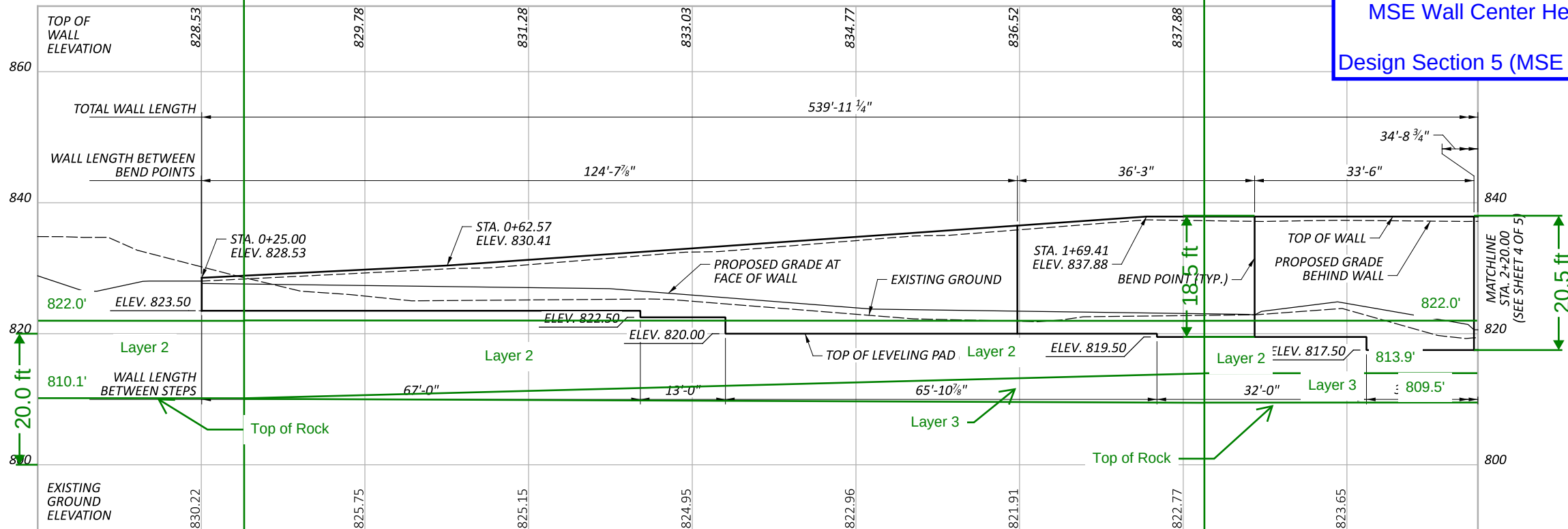
#	Metal strip Elevation [ft]	Metal strip Length [ft]	e / L Static	e / L Seismic	Metal strip Type #	Product name
1	1.05	15.00	0.1707	N/A	1	---
2	3.15	15.00	0.1410	N/A	1	---
3	5.25	15.00	0.1140	N/A	1	---
4	7.35	15.00	0.0898	N/A	1	---
5	9.45	15.00	0.0684	N/A	1	---
6	11.55	15.00	0.0497	N/A	1	---
7	13.65	15.00	0.0338	N/A	1	---
8	15.75	15.00	0.0207	N/A	1	---
9	17.85	15.00	0.0103	N/A	1	---
10	19.95	15.00	0.0028	N/A	1	---

Sta 6+17/Sta 8+48
13.5' Wall

Design Section 3



PLAN



ELEVATION (1 OF 3)

BENCHMARK DATA

BM T9 (MAGS)	STA. 264+09.05	ELEV. 821.779	OFFSET 58.74' LT.
BM SV2 (MAGS)	STA. 262+72.65	ELEV. 822.721	OFFSET 139.75' LT.

FOR ADDITIONAL BENCHMARK INFORMATION, SEE ROADWAY PLANS.

NOTES

1. EARTHWORK LIMITS SHOWN ARE APPROXIMATE. ACTUAL SLOPES SHALL CONFORM TO PLAN CROSS SECTIONS.

MSE Wall Design Sections:

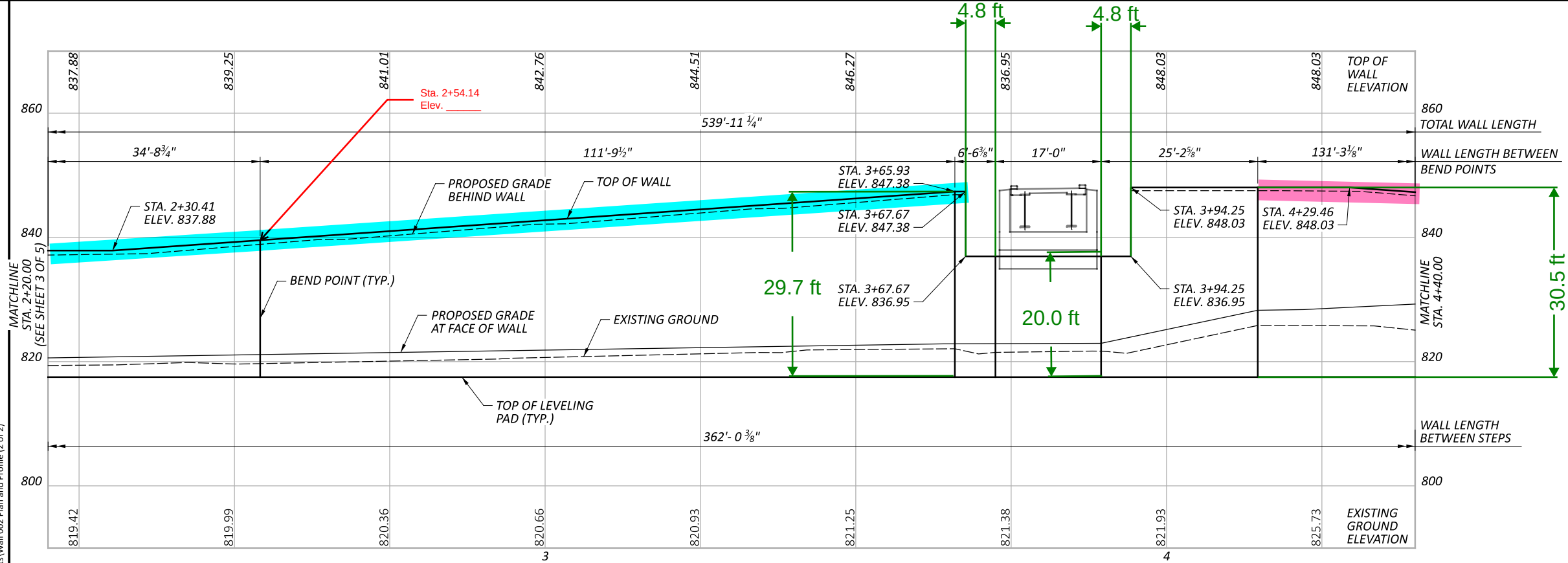
Design Section 1
MSE Along Ramp Upslope of SR-126

Design Section 2 (MSE Wall at switch-back)

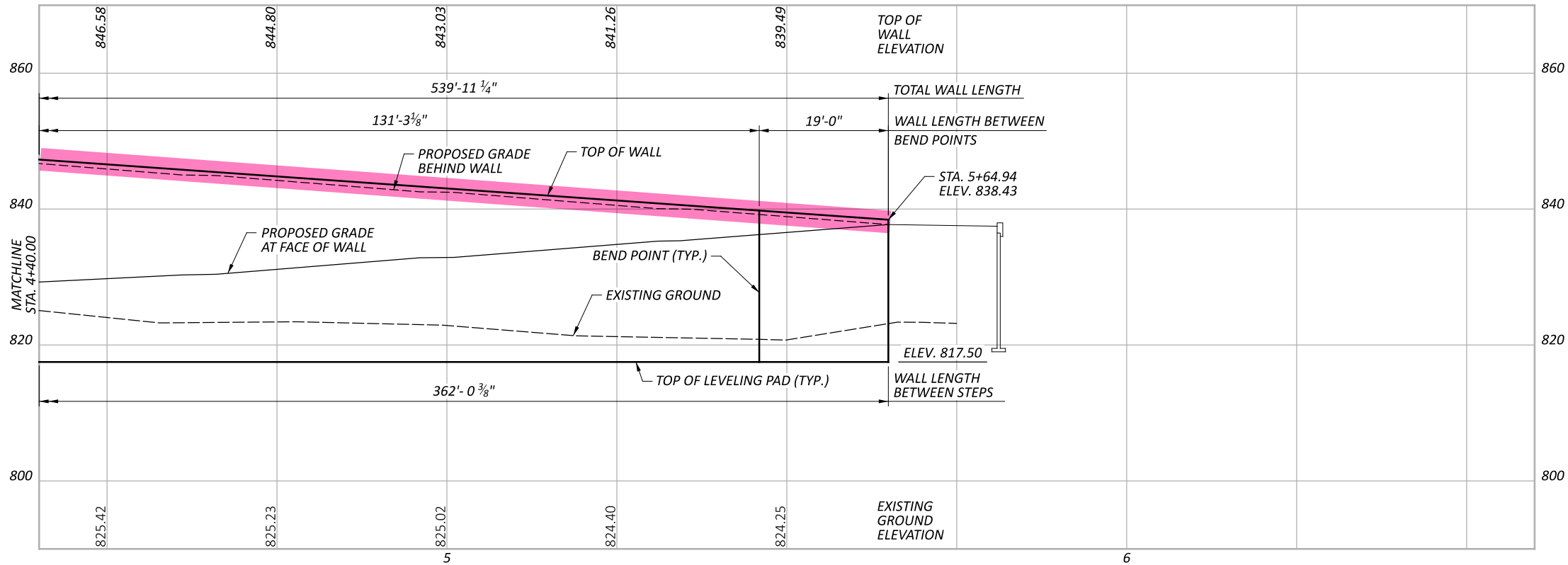
Design Section 3 Back to Back MSE Wall Upper Ramp

Design Section 4
MSE Wall Abutment
MSE Wall Back-to-Back Ramp walls
MSE Wall Center Height Back to Back Wall

Design Section 5 (MSE Wall - End Wall - Full Ramp Height)



ELEVATION (2 OF 3)

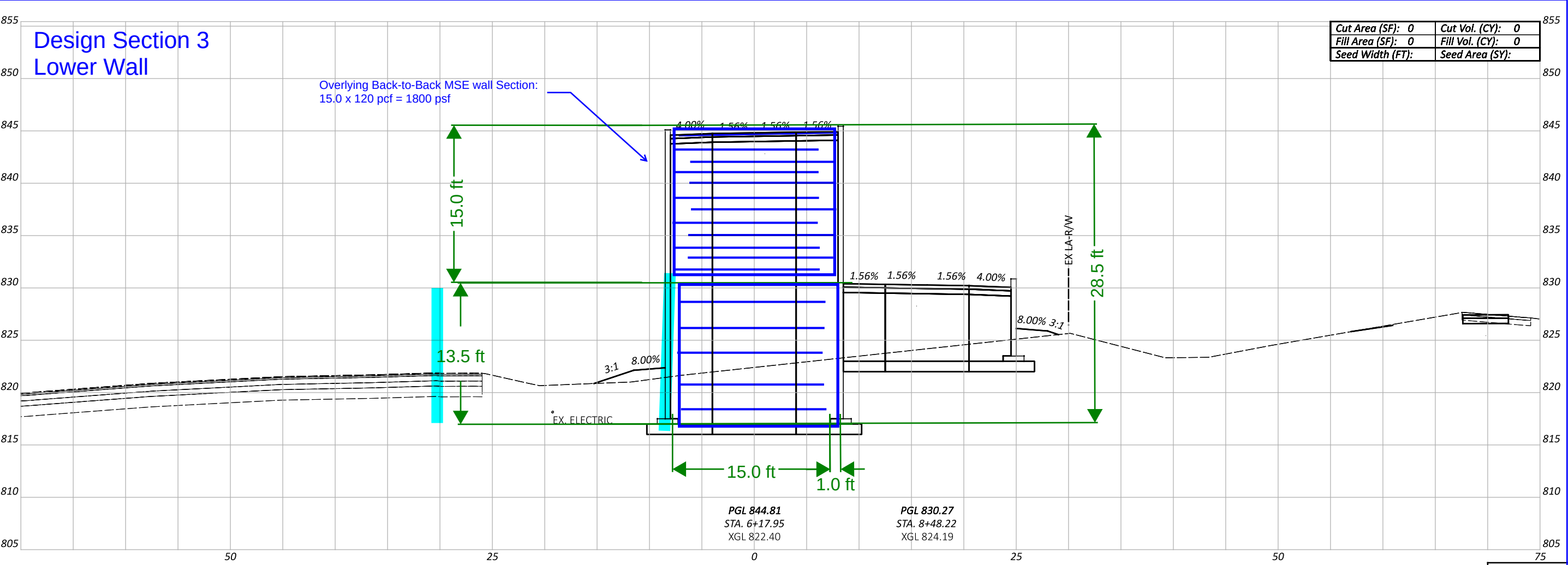


ELEVATION (3 OF 3)

WALL PLAN AND ELEVATION (2 OF 2)
WALL 002
ALONG NORTH APPROACH

SFN	
N/A	
DESIGN AGENCY	
	
9999 CARVER ROAD SUITE 210 CINCINNATI, OH 45242 513.984.7500	
DESIGNER	CHECKER
RBK	XXX
REVIEWER	
XXX MM-DD-YY	
PROJECT ID	
114652	
SUBSET	TOTAL
4	5
SHEET	TOTAL
P.28	31

Forward Abutment Wall (North)



Sheet Totals			114652	
Seeding	Cut	Fill	SHEET	TOTAL
P.20				32

CROSS SECTIONS
STA. 6+17.95 AND STA. 8+48.22

DESIGN AGENCY

DESIGNER

MJL

REVIEWER

XXX MM-DD-YY

PROJECT ID

114652

MSEW(3.0): Update # 14.4

License number MSEW-302528

SOIL DATA

REINFORCED SOIL

Unit weight, γ	120.0 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	30.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{\text{equiv.}}$	130.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{\text{equiv.}}$	0.0 °
Equivalent cohesion, $c_{\text{equiv.}}$	2400.0 lb/ft ²

Water table is at wall base elevation

LATERAL EARTH PRESSURE COEFFICIENTS

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

K_a (external stability) = 0.3333 (if batter is less than 10° , K_a is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): $N_c = 5.14$ $N_\gamma = 0.00$

SEISMICITY

Not Applicable

D A T A	Metal strip type #1	Metal strip type #2	Metal strip type #3	Metal strip type #4	Metal strip type #5
Yield strength of steel, F_y [kips/in ²]	65.3	N/A	N/A	N/A	N/A
Gross width of strip, b [in]	2.0	N/A	N/A	N/A	N/A
Vertical spacing, S_v [ft]	Varies	N/A	N/A	N/A	N/A
Design cross section area, A_c [in ²]	0.23	N/A	N/A	N/A	N/A
Smooth steel strips.					
Friction angle along reinforcement-soil interface,	ρ				
@ the top	17.35	N/A	N/A	N/A	N/A
@ 19.7 ft or below	17.35	N/A	N/A	N/A	N/A
Pullout resistance factor, F^*					
@ the top	0.31	N/A	N/A	N/A	N/A
@ 19.7 ft or below	0.31	N/A	N/A	N/A	N/A
Scale-effect correction factor, α	1.00	N/A	N/A	N/A	N/A

Variation of Lateral Earth Pressure Coefficient With Depth

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

Design height, Hd	13.50	[ft]	{ Embedded depth is E = 3.00 ft, and height above top of finished bottom grade is H = 10.50 ft }
Batter, ω	0.0	[deg]	
Backslope, β	0.0	[deg]	
Backslope rise	0.0	[ft]	Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)

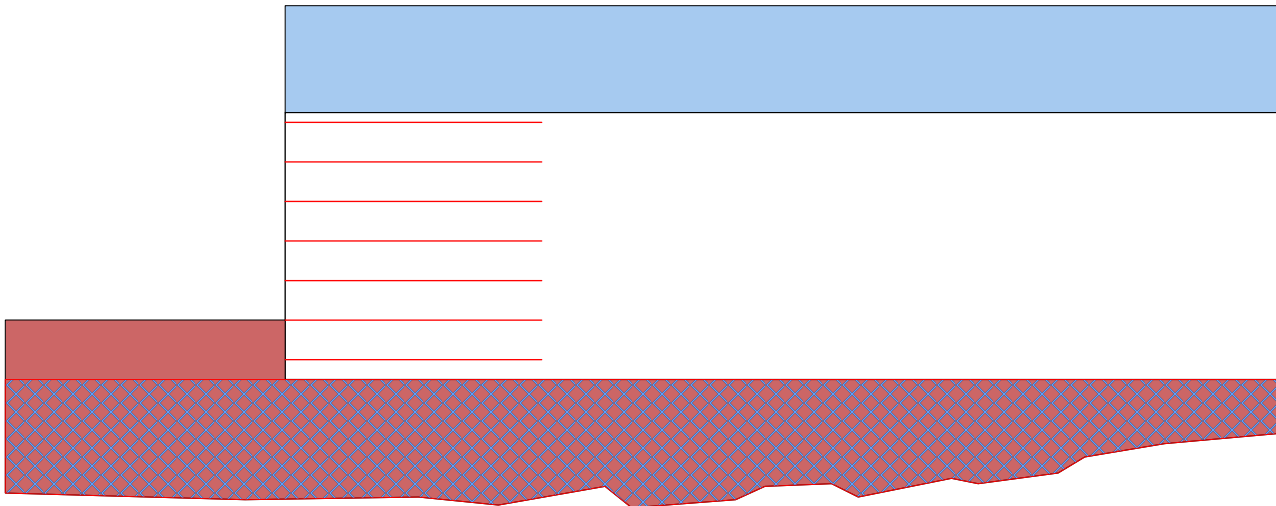
UNIFORM SURCHARGE

Uniformly distributed dead load is 1800.0 [lb/ft²], and live load is 250.0 [lb/ft²]

Hydrostatic water pressure exist in analysis. hw1 = 0.00 and hw2 = 0.00 ft.

Overlying Back-to-Back MSE wall Section:
15.0 x 120 pcf = 1800 psf

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 8 10 [ft]

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, $CDR = 1.10$, factored bearing load = 7259 lb/ft².

Foundation Interface: Direct sliding, CDR = 1.531, Eccentricity, $e/L = 0.2075$, CDR-overturning = 2.41

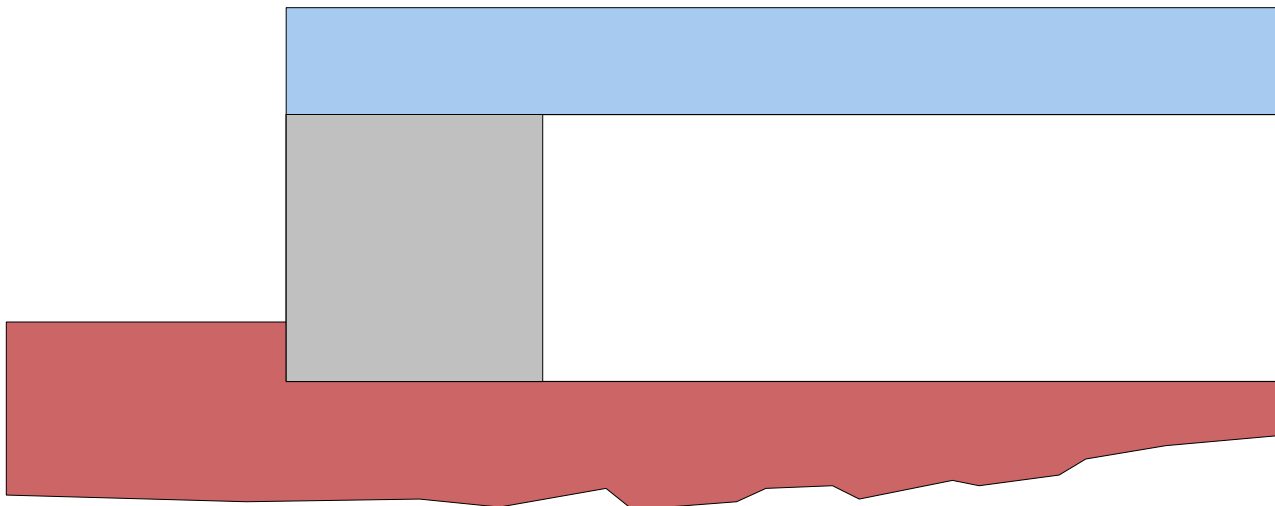
METAL STRIP				CONNECTION							
#	Elevation [ft]	Length [ft]	Type #	CDR [pullout resistance]	CDR [connection break]	CDR [metal strip strength]	Metal strip strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	1.00	13.00	1	N/A	1.04	1.16	1.156	0.383	1.571	0.1815	---
2	3.00	13.00	1	N/A	1.07	1.18	1.183	0.328	1.811	0.1339	---
3	5.00	13.00	1	N/A	1.09	1.22	1.216	0.278	2.156	0.0922	---
4	7.00	13.00	1	N/A	1.14	1.27	1.265	0.236	2.705	0.0570	---
5	9.00	13.00	1	N/A	1.20	1.34	1.339	0.227	3.723	0.0291	---
6	11.00	13.00	1	N/A	1.28	1.42	1.422	0.216	6.336	0.0096	---
7	13.00	13.00	1	N/A	1.80	2.00	1.997	0.269	29.648	0.0004	---

[illegible]

BEARING CAPACITY for GIVEN LAYOUT

	STATIC	SEISMIC	UNITS
(Water table is at wall base elevation)			
Factored bearing resistance, q_n	8021	N/A	[lb/ft ²]
Factored bearing load, σ_v	7259.1	N/A	[lb/ft ²]
Eccentricity, e	1.73	N/A	[ft]
Eccentricity, e/L	0.133	N/A	
CDR calculated	1.10	N/A	
Base length	13.00	N/A	[ft]

Unfactored applied bearing pressure = (Unfactored R) / [L - 2 * (Unfactored e)] =
Unfactored R = 47709.97 [lb/ft], L = 13.00, Unfactored e = 1.65 [ft], and Sigma = 4917.49 [lb/ft²]



SCALE:

0 2 4 6 8 10 [ft]

DIRECT SLIDING for GIVEN LAYOUT (for METAL STRIPS reinforcements)

Along reinforced and foundation soils interface: CDR-static = 1.531

#	Metal strip Elevation [ft]	Metal strip Length [ft]	CDR Static	CDR Seismic	Metal strip Type #	Product name
1	1.00	13.00	1.571	N/A	1	---
2	3.00	13.00	1.811	N/A	1	---
3	5.00	13.00	2.156	N/A	1	---
4	7.00	13.00	2.705	N/A	1	---
5	9.00	13.00	3.723	N/A	1	---
6	11.00	13.00	6.336	N/A	1	---
7	13.00	13.00	29.648	N/A	1	---

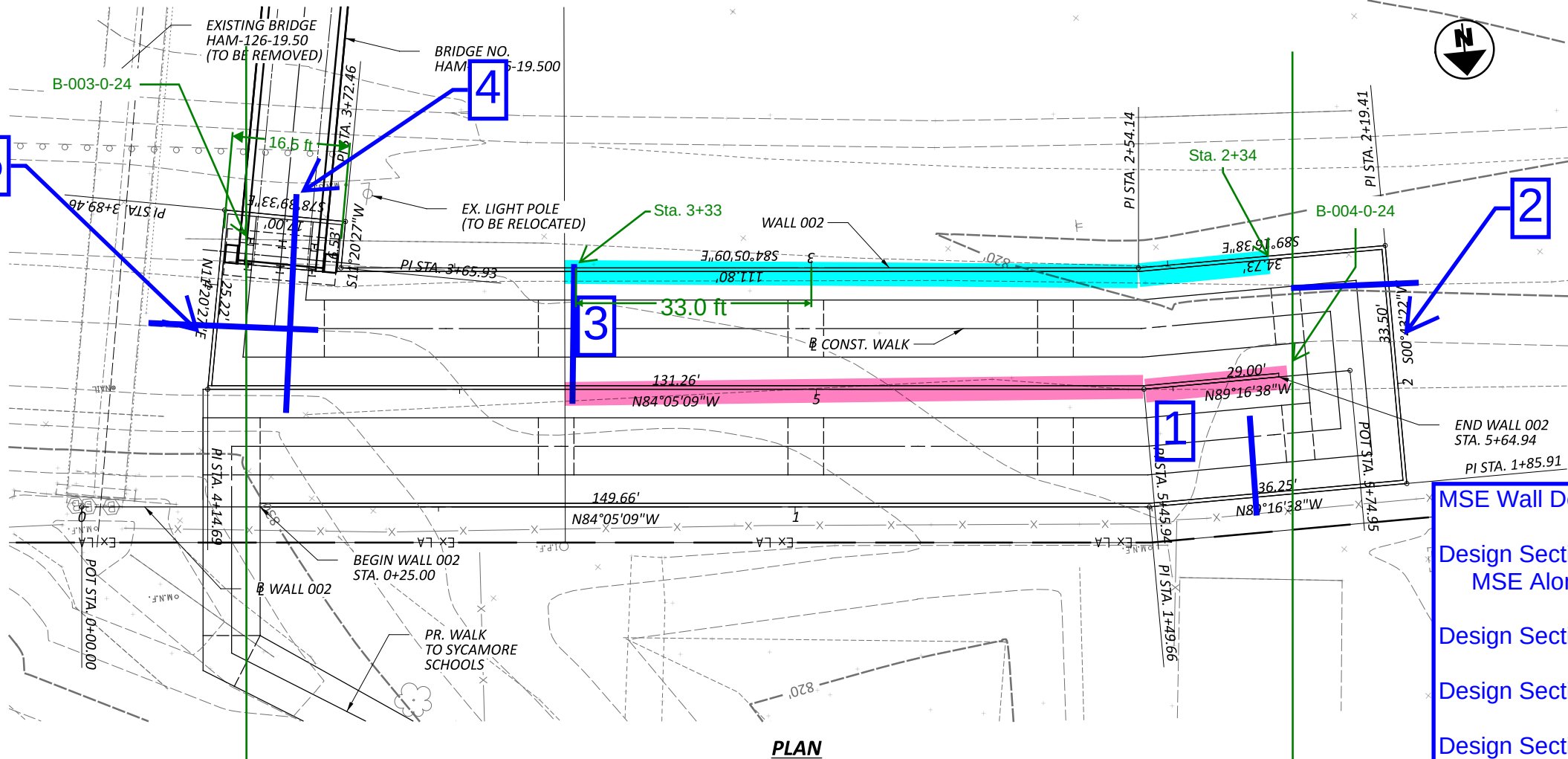
ECCENTRICITY for GIVEN LAYOUT (for Simplified Method)

At interface with foundation: e/L static = 0.2075; Overturning: CDR-static = 2.41

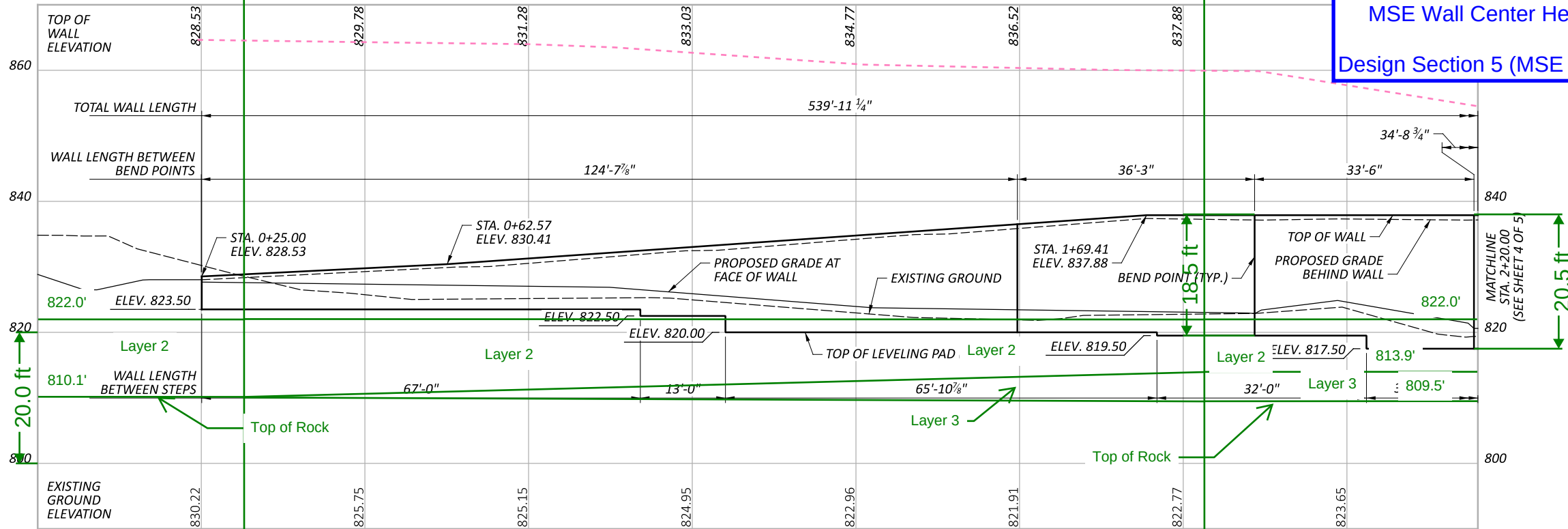
#	Metal strip Elevation [ft]	Metal strip Length [ft]	e / L Static	e / L Seismic	Metal strip Type #	Product name
1	1.00	13.00	0.1815	N/A	1	---
2	3.00	13.00	0.1339	N/A	1	---
3	5.00	13.00	0.0922	N/A	1	---
4	7.00	13.00	0.0570	N/A	1	---
5	9.00	13.00	0.0291	N/A	1	---
6	11.00	13.00	0.0096	N/A	1	---
7	13.00	13.00	0.0004	N/A	1	---

Sta 6+17/Sta 8+48
15.0' Wall

Design Section 3



PLAN



ELEVATION (1 OF 3)

BENCHMARK DATA

BM T9 (MAGS)	STA. 264+09.05	ELEV. 821.779	OFFSET 58.74' LT.
BM SV2 (MAGS)	STA. 262+72.65	ELEV. 822.721	OFFSET 139.75' LT.

FOR ADDITIONAL BENCHMARK INFORMATION, SEE ROADWAY PLANS.

NOTES

1. EARTHWORK LIMITS SHOWN ARE APPROXIMATE. ACTUAL SLOPES SHALL CONFORM TO PLAN CROSS SECTIONS.

MSE Wall Design Sections:

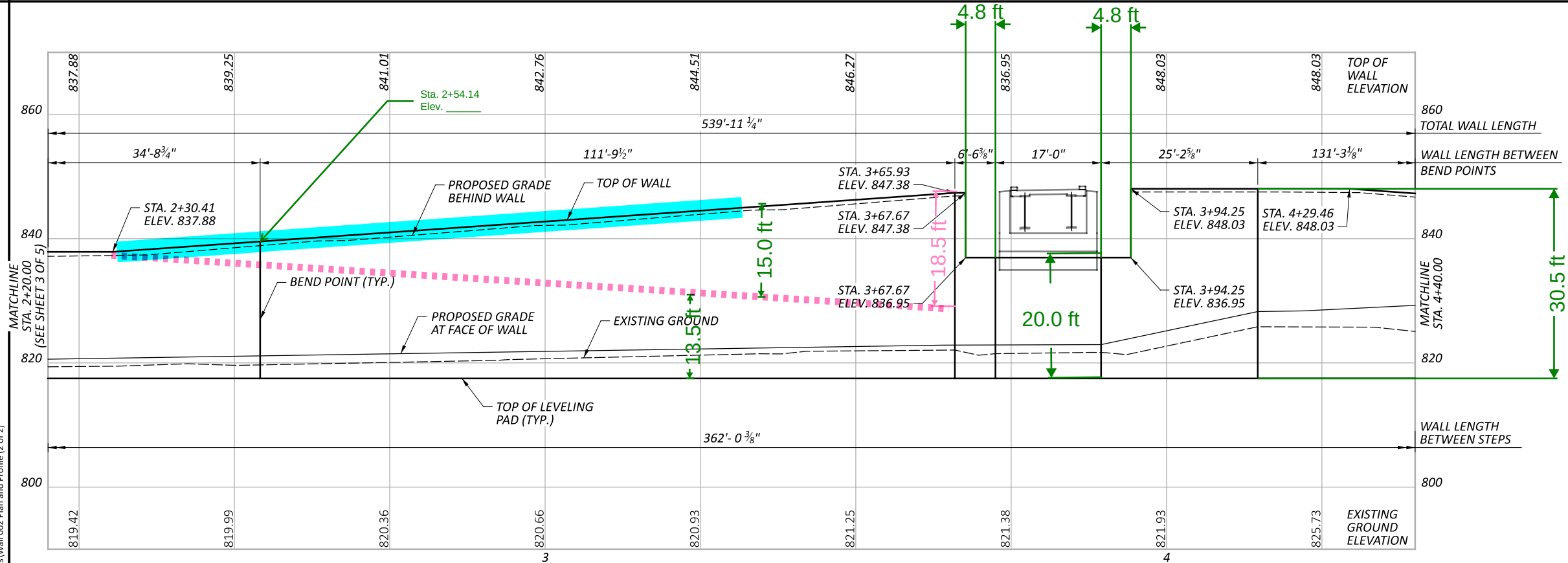
Design Section 1
MSE Along Ramp Upslope of SR-126

Design Section 2 (MSE Wall at switch-back)

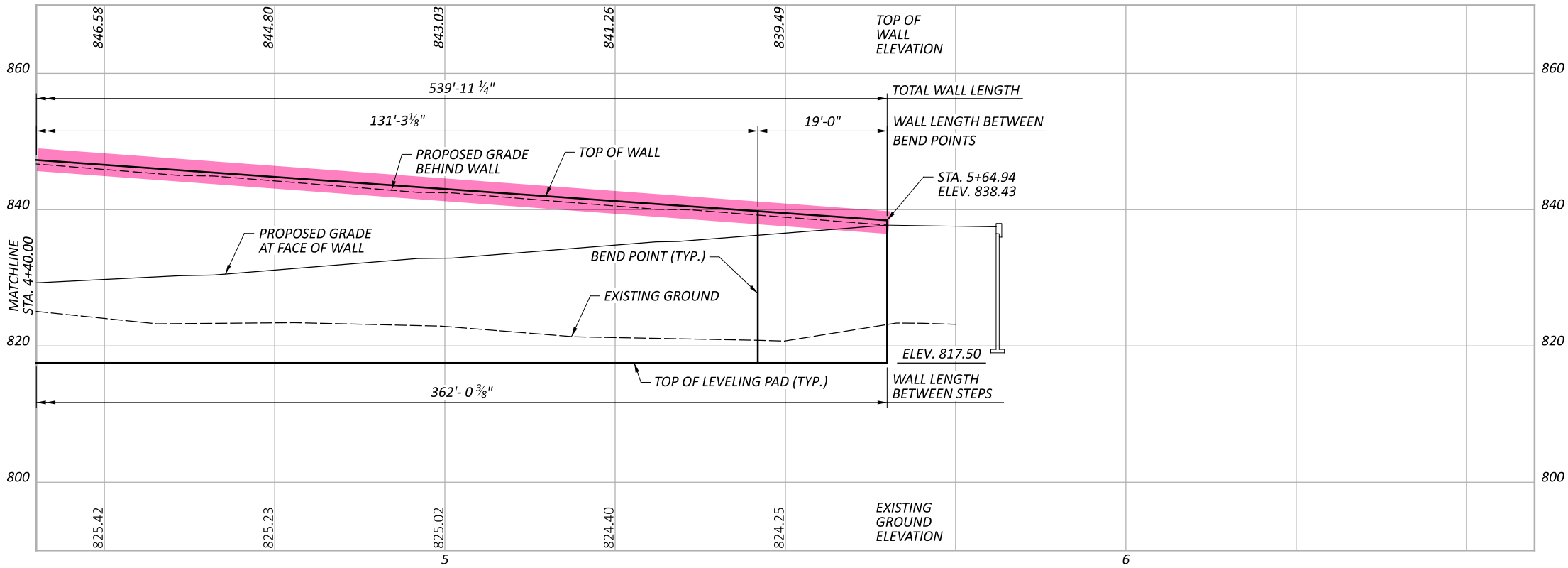
Design Section 3 Back to Back MSE Wall Upper Ramp

Design Section 4
MSE Wall Abutment
MSE Wall Back-to-Back Ramp walls
MSE Wall Center Height Back to Back Wall

Design Section 5 (MSE Wall - End Wall - Full Ramp Height)



ELEVATION (2 OF 3)

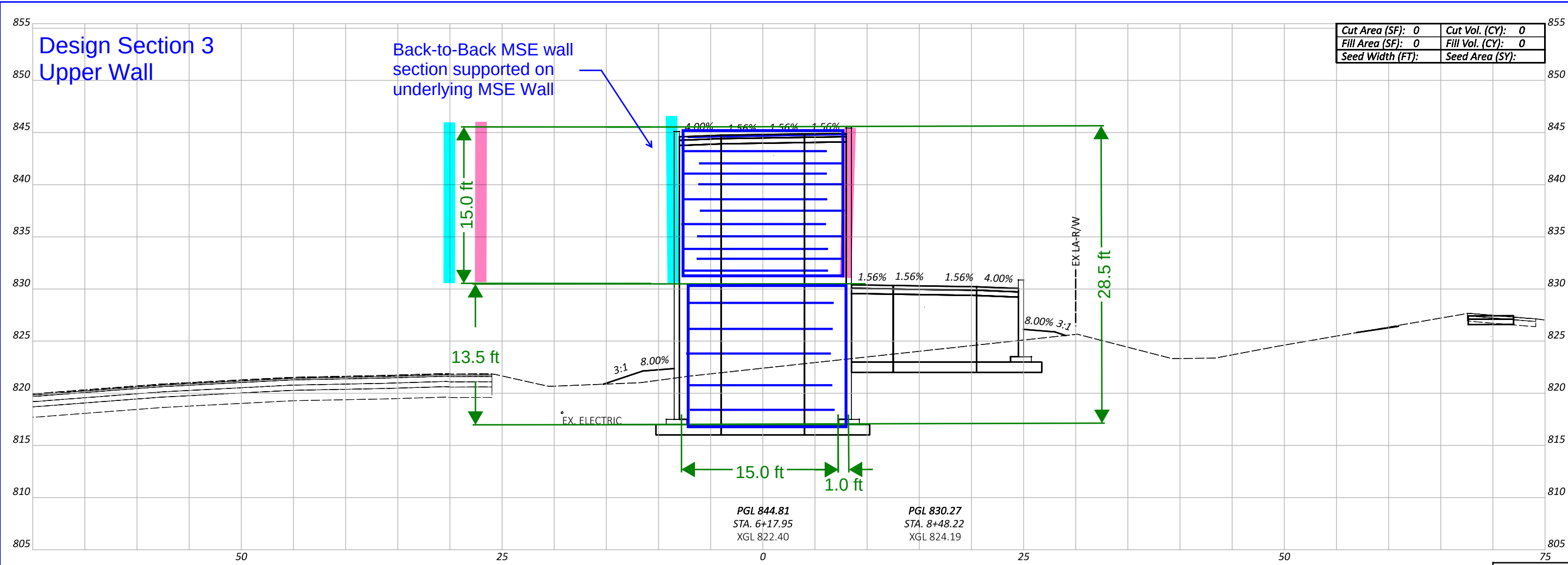


ELEVATION (3 OF 3)

WALL PLAN AND ELEVATION (2 OF 2)
WALL 002
ALONG NORTH APPROACH

SFN	
N/A	
DESIGN AGENCY	
	
9999 CARVER ROAD SUITE 210 CINCINNATI, OH 45242 513.984.7500	
DESIGNER	CHECKER
RBK	XXX
REVIEWER	
XXX MM-DD-YY	
PROJECT ID	
114652	
SUBSET	TOTAL
4	5
SHEET	TOTAL
P.28	31

Forward Abutment Wall (North)



Cut Area (SF):	0	Cut Vol. (CY):	0
Fill Area (SF):	0	Fill Vol. (CY):	0
Seed Width (FT):		Seed Area (SY):	

Sheet Totals		
Seeding	Cut	Fill

CROSS SECTIONS
STA. 6+17.95 AND STA. 8+48.22

DESIGN AGENCY



DESIGNER

MJL

REVIEWER

XXX MM-DD-YY

PROJECT ID

114652

SHEET

P.20

TOTAL

32

MSEW(3.0): Update # 14.4

License number MSEW-302528

SOIL DATA

REINFORCED SOIL

Unit weight, γ	120.0 lb/ft ³
Design value of internal angle of friction, ϕ	34.0 °

The material is split between Reinforced and "Retained". For conservatism will keep as 30*

RETAINED SOIL

Unit weight, γ	120.0 lb/ft ³
Design value of internal angle of friction, ϕ	30.0 ° 

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{\text{equiv.}}$		120.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{\text{equiv.}}$		34.0 °
Equivalent cohesion, $c_{\text{equiv.}}$		0.0 lb/ft ²

Back-to-Back MSE wall
- section supported on
underlying MSE Wall

Water table is at wall base elevation

LATERAL EARTH PRESSURE COEFFICIENTS

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

K_a (external stability) = 0.3333 (if batter is less than 10° , K_a is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): $N_c = 42.16$ $N_\gamma = 41.06$

SEISMICITY

Not Applicable

INPUT DATA: Metal strips (Analysis)

D A T A	Metal strip type #1	Metal strip type #2	Metal strip type #3	Metal strip type #4	Metal strip type #5
Yield strength of steel, F_y [kips/in ²]	65.3	N/A	N/A	N/A	N/A
Gross width of strip, b [in]	2.0	N/A	N/A	N/A	N/A
Vertical spacing, S_v [ft]	Varies	N/A	N/A	N/A	N/A
Design cross section area, A_c [in ²]	0.23	N/A	N/A	N/A	N/A

Ribbed steel strips.

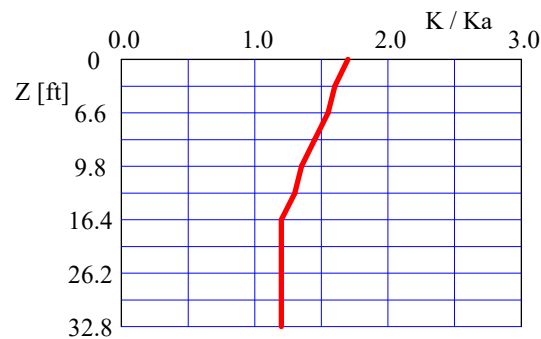
Uniformity Coefficient of reinforced soil, $C_u = D_{60}/D_{10} = 4.0$

Friction angle along reinforcement-soil interface,	ρ				
@ the top	60.97	N/A	N/A	N/A	N/A
@ 19.7 ft or below	32.00	N/A	N/A	N/A	N/A
Pullout resistance factor, F^*					
@ the top	1.80	N/A	N/A	N/A	N/A
@ 19.7 ft or below	0.62	N/A	N/A	N/A	N/A
Scale-effect correction factor, α	1.00	N/A	N/A	N/A	N/A

Note: Z for calculating K/Ka and F* is measured from roadway surface (FHWA-NHI-10-024).

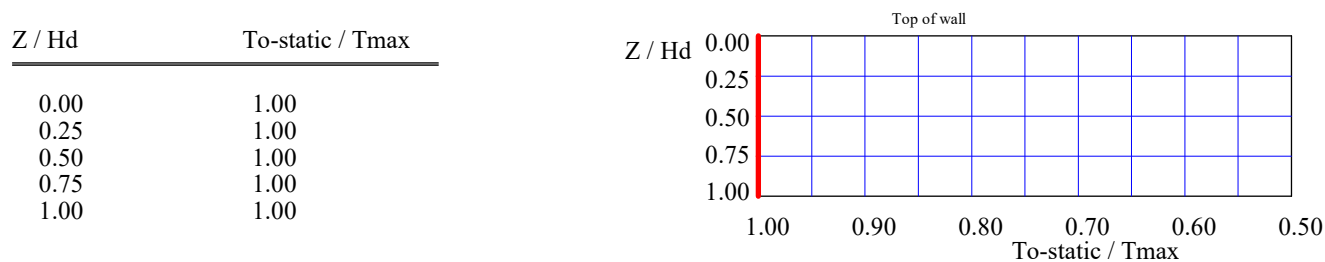
Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.70
3.3 ft	1.60
6.6 ft	1.55
9.8 ft	1.45
13.1 ft	1.35
16.4 ft	1.30
19.7 ft	1.20



INPUT DATA: Facia and Connection (Analysis)

FACIA type: Segmental precast concrete panels.
Depth of panel is 0.50 ft. Horizontal distance to Center of Gravity of panel is 0.25 ft.
Average unit weight of panel is $\gamma_f = 152.78 \text{ lb/ft}^3$

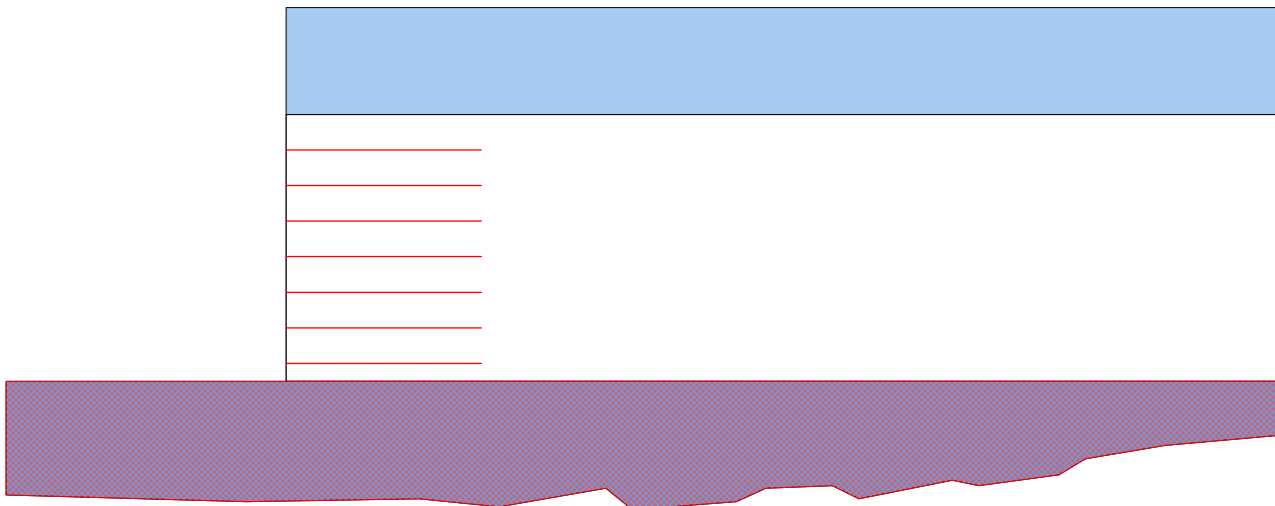


D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	---	N/A	N/A	N/A	N/A
Strength reduction at the connection, CRu = Fyc / Fy	0.90	N/A	N/A	N/A	N/A

Design height, Hd	15.00	[ft]	{ Embedded depth is E = 0.00 ft, and height above top of finished bottom grade is H = 15.00 ft }
Batter, ω	0.0	[deg]	
Backslope, β	0.0	[deg]	Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)
Backslope rise	0.0	[ft]	

Uniformly distributed dead load is 0.0 [lb/ft²], and live load is 250.0 [lb/ft²]

ANALYZED REINFORCEMENT LAYOUT:



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:	γ_{p-EV}	1.35	
Load factor for earthquake loads, EQ, from Table 3.4.1-1:	γ_{p-EQ}	1.00	
Load factor for live load surchrge, LS, from Figure C11.5.5-3(b): (Same as in External Stability).	γ_{p-LS}	1.75	
Load factor for dead load surchrge, ES: (Same as in External Stability).	γ_{p-ES}	1.50	
Resistance factor for reinforcement tension from Table 11.5.6-1: Metal Strips:	ϕ	Static 0.75	Combined static/seismic 1.00
Resistance factor for reinforcement tension in connectors from Table 11.5.6-1: Metal Strips:	ϕ	Static 0.75	Combined static/seismic 1.00
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 γ_{p-EV}	1.00	γ_{p-EQ} 1.00
Bearing Capacity γ_{p-EV}	1.35	γ_{p-EQ} 1.35
Load factor of active lateral earth pressure, EH, from Table 3.4.1-2 and Figure C11.5.5-2:	γ_{p-EH}	1.50
Load factor of active lateral earth pressure during earthquake (does not multiply P_{AE} and P_{IR}):	$(\gamma_{p-EH})_{EQ}$	1.50
Load factor for earthquake loads, EQ, from Table 3.4.1-1 (multiplies P_{AE} and P_{IR}):	γ_{p-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, $CDR = 1.49$, factored bearing load = 4034 lb/ft^2 .

Foundation Interface: Direct sliding, CDR = 1.494, Eccentricity, $e/L = 0.2303$, CDR-overturning = 2.17

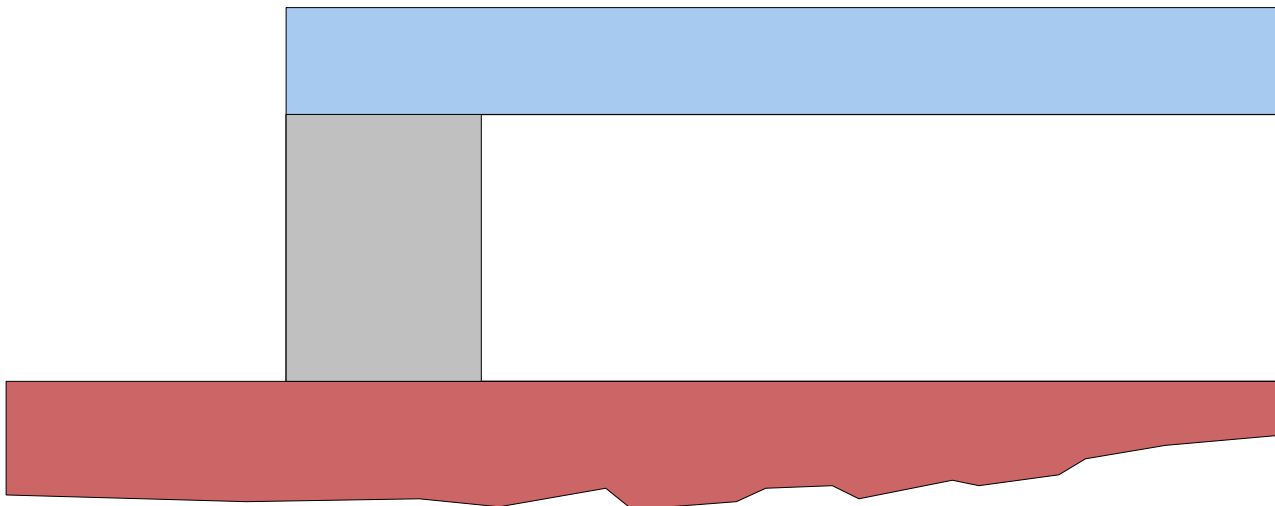
M E T A L S T R I P				C O N N E C T I O N			Metal strip strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
#	Elevation [ft]	Length [ft]	Type #	CDR [pullout resistance]	CDR [connection break]	CDR [metal strip strength]					
1	1.00	11.00	1	N/A	2.04	2.26	2.263	0.989	1.574	0.2053	---
2	3.00	11.00	1	N/A	2.24	2.49	2.486	0.926	1.760	0.1594	---
3	5.00	11.00	1	N/A	2.48	2.76	2.756	0.826	1.997	0.1191	---
4	7.00	11.00	1	N/A	2.83	3.14	3.140	0.703	2.308	0.0843	---
5	9.00	11.00	1	N/A	3.36	3.74	3.738	0.655	2.733	0.0549	---
6	11.00	11.00	1	N/A	4.27	4.74	4.745	0.600	3.349	0.0311	---
7	13.00	11.00	1	N/A	4.40	4.89	4.894	0.333	4.326	0.0128	---

BEARING CAPACITY for GIVEN LAYOUT

	STATIC	SEISMIC	UNITS
(Water table is at wall base elevation)			
Factored bearing resistance, q-n	6006	N/A	[lb/ft ²]
Factored bearing load, σ_v	4033.7	N/A	[lb/ft ²]
Eccentricity, e	1.59	N/A	[ft]
Eccentricity, e/L	0.145	N/A	
CDR calculated	1.49	N/A	
Base length	11.00	N/A	[ft]

$$\text{Unfactored applied bearing pressure} = (\text{Unfactored R}) / [L - 2 * (\text{Unfactored e})] =$$

Unfactored R = 22549.99 [lb/ft], L = 11.00, Unfactored e = 1.41 [ft], and Sigma = 2759.10 [lb/ft²]



SCALE:

0 2 4 6 8 10 [ft]



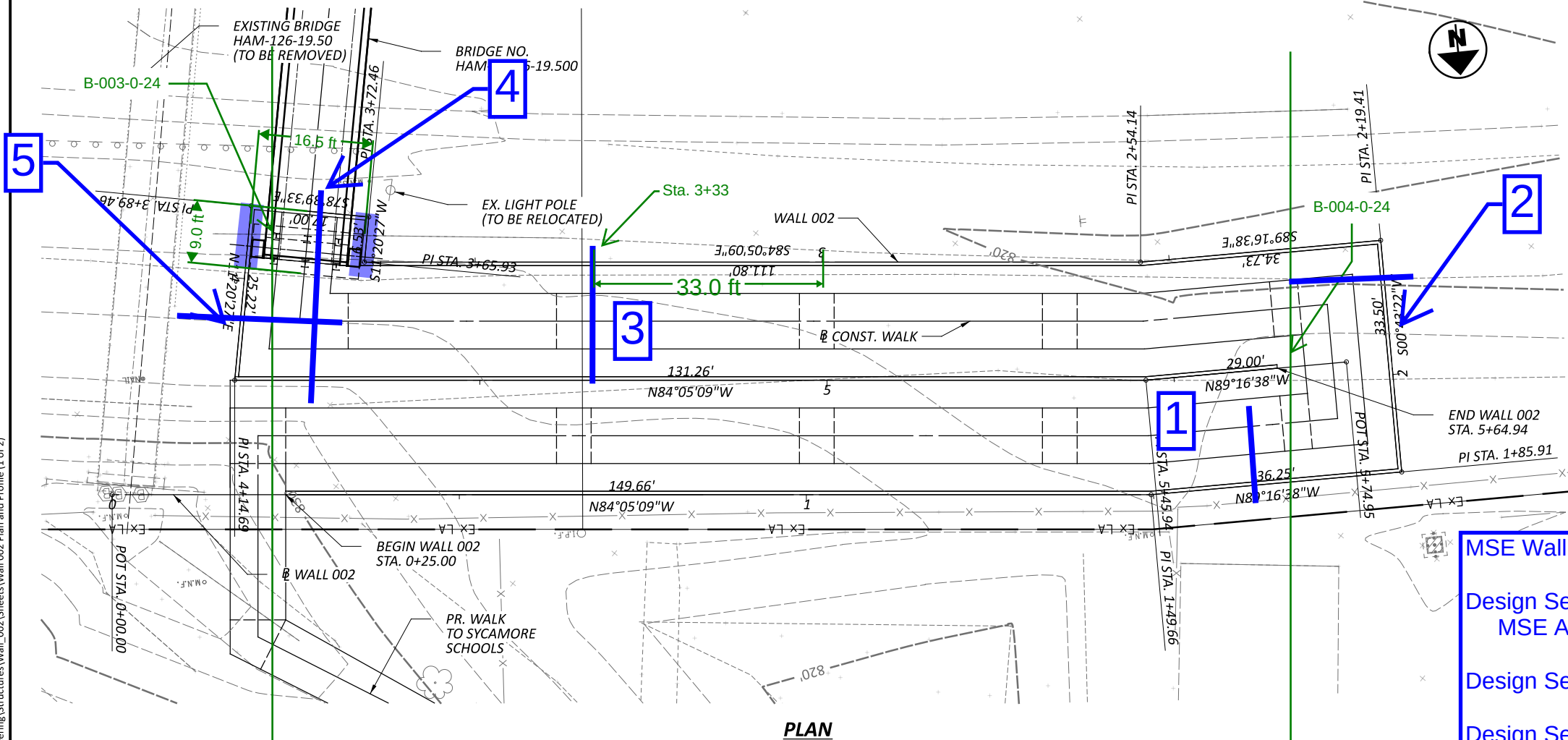
DIRECT SLIDING for GIVEN LAYOUT (for METAL STRIPS reinforcements)

Along reinforced and foundation soils interface: CDR-static = 1.494

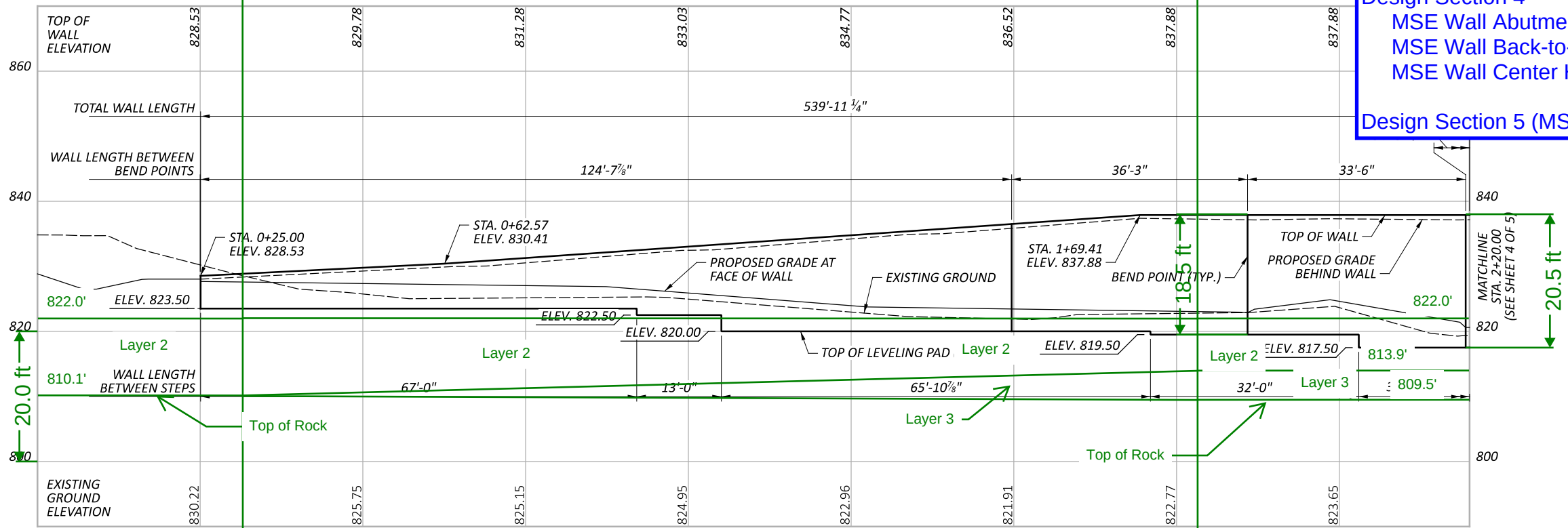
#	Metal strip Elevation [ft]	Metal strip Length [ft]	CDR Static	CDR Seismic	Metal strip Type #	Product name
1	1.00	11.00	1.574	N/A	1	---
2	3.00	11.00	1.760	N/A	1	---
3	5.00	11.00	1.997	N/A	1	---
4	7.00	11.00	2.308	N/A	1	---
5	9.00	11.00	2.733	N/A	1	---
6	11.00	11.00	3.349	N/A	1	---
7	13.00	11.00	4.326	N/A	1	---

Sta 5+82/Sta 8+83
18.0' Wall
(Abutment)

Design Section 4



PLAN



ELEVATION (1 OF 3)

BENCHMARK DATA

BM T9 (MAGS)	STA. 264+09.05	ELEV. 821.779	OFFSET 58.74' LT.
BM SV2 (MAGS)	STA. 262+72.65	ELEV. 822.721	OFFSET 139.75' LT.

FOR ADDITIONAL BENCHMARK INFORMATION, SEE ROADWAY PLANS.

NOTES

1. EARTHWORK LIMITS SHOWN ARE APPROXIMATE. ACTUAL SLOPES SHALL CONFORM TO PLAN CROSS SECTIONS.

MSE Wall Design Sections:

Design Section 1

MSE Along Ramp Upslope of SR-126

Design Section 2 (MSE Wall at switch-back)

Design Section 3 Back to Back MSE Wall Upper Ramp

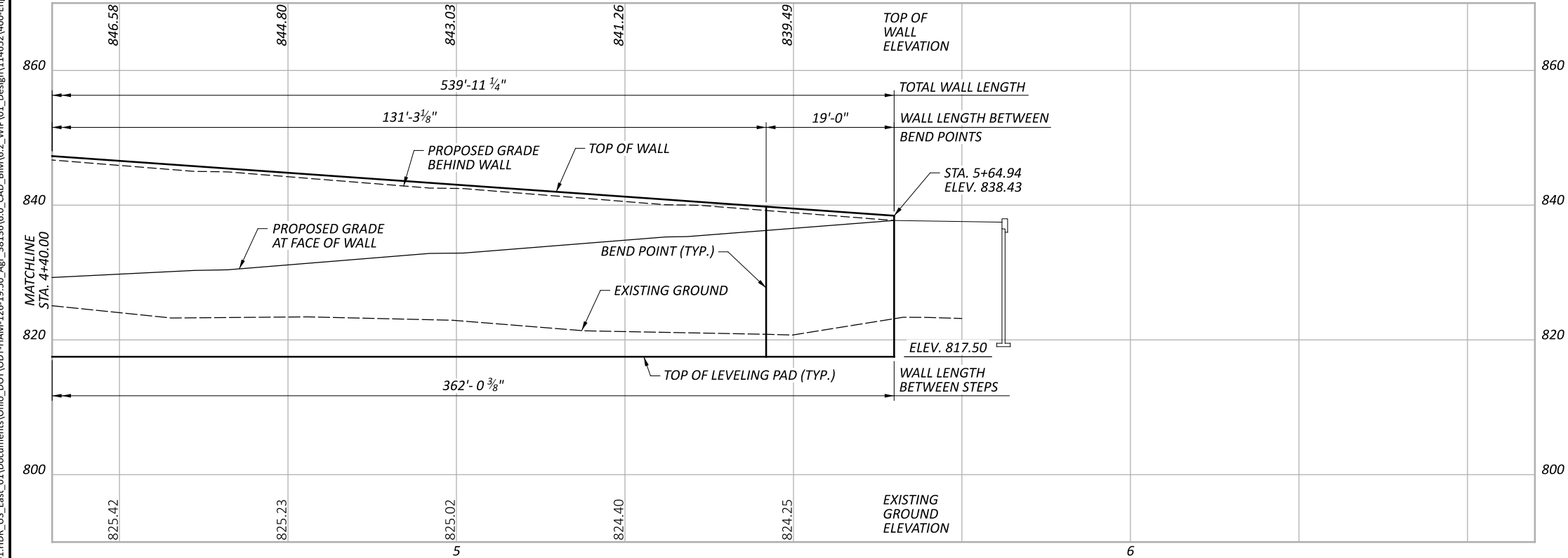
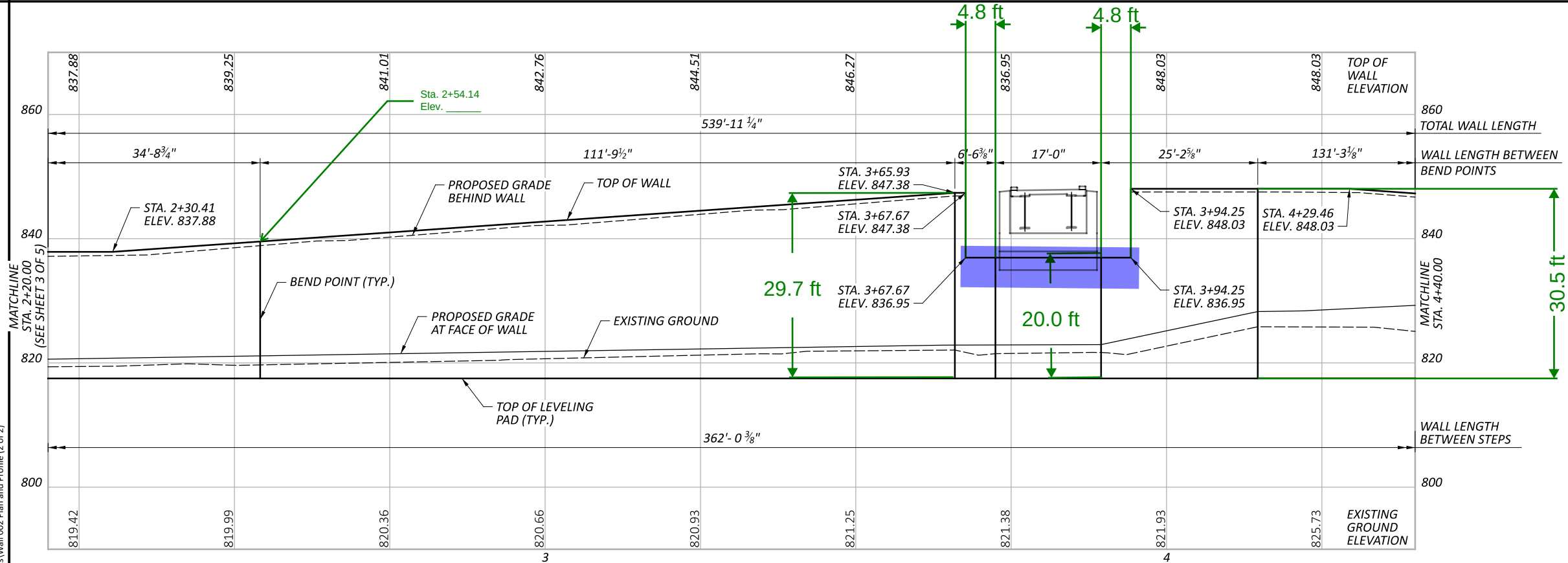
Design Section 4

MSE Wall Abutment

MSE Wall Back-to-Back Ramp walls

MSE Wall Center Height Back to Back Wall

Design Section 5 (MSE Wall - End Wall - Full Ramp Height)

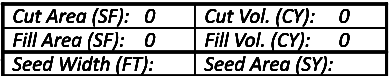


WALL PLAN AND ELEVATION (2 OF 2)
WALL 002
ALONG NORTH APPROACH

SFN	
N/A	
DESIGN AGENCY	
	
9999 CARVER ROAD SUITE 210 CINCINNATI, OH 45242 513.984.7500	
DESIGNER	CHECKER
RBK	XXX
REVIEWER	
XXX MM-DD-YY	
PROJECT ID	
114652	
SUBSET	TOTAL
4	5
SHEET	TOTAL
P.28	31

Design Section 4

Abutment



Sheet Totals		
Seeding	Cut	F

HDR

REVIEWER
XX MM-DD-Y

PROJECT ID
114652

CROSS SECTIONS
STA. 5+82.95 AND STA. 8+83.22

MSEW(3.0): Update # 14.4

License number MSEW-302528

SOIL DATA

REINFORCED SOIL

Unit weight, γ	120.0 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	30.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{\text{equiv.}}$	130.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{\text{equiv.}}$	0.0 °
Equivalent cohesion, $c_{\text{equiv.}}$	2400.0 lb/ft ²

Water table is at wall base elevation

LATERAL EARTH PRESSURE COEFFICIENTS

$$K_a \text{ (internal stability)} = 0.2827 \quad (\text{if batter is less than } 10^\circ, K_a \text{ is calculated from eq. 15. Otherwise, eq. 38 is utilized})$$

K_a (external stability) = 0.3333 (if batter is less than 10° , K_a is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): $N_c = 5.14$ $N_\gamma = 0.00$

SEISMICITY

Not Applicable

INPUT DATA: Metal strips (Analysis)

D A T A	Metal strip type #1	Metal strip type #2	Metal strip type #3	Metal strip type #4	Metal strip type #5
Yield strength of steel, F_y [kips/in ²]	65.3	N/A	N/A	N/A	N/A
Gross width of strip, b [in]	2.0	N/A	N/A	N/A	N/A
Vertical spacing, S_v [ft]	Varies	N/A	N/A	N/A	N/A
Design cross section area, A_c [in ²]	0.23	N/A	N/A	N/A	N/A

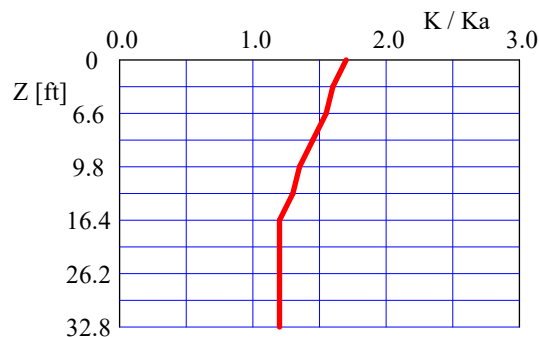
Smooth steel strips.

Friction angle along reinforcement-soil interface,	ρ				
@ the top	17.35	N/A	N/A	N/A	N/A
@ 19.7 ft or below	17.35	N/A	N/A	N/A	N/A
Pullout resistance factor, F^*					
@ the top	0.31	N/A	N/A	N/A	N/A
@ 19.7 ft or below	0.31	N/A	N/A	N/A	N/A
Scale-effect correction factor, α	1.00	N/A	N/A	N/A	N/A

Note: Z for calculating K/K_a and F^* is measured from roadway surface (FHWA-NHI-10-024).

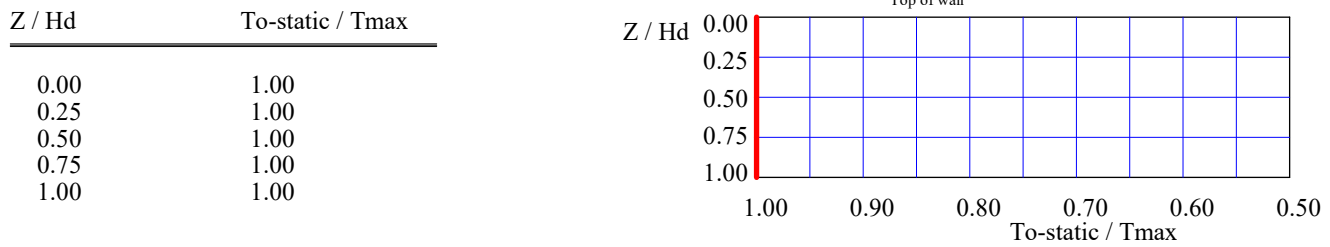
Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.70
3.3 ft	1.60
6.6 ft	1.55
9.8 ft	1.45
13.1 ft	1.35
16.4 ft	1.30
19.7 ft	1.20



INPUT DATA: Facia and Connection (Analysis)

FACIA type: Segmental precast concrete panels.
 Depth of panel is 0.50 ft. Horizontal distance to Center of Gravity of panel is 0.25 ft.
 Average unit weight of panel is $\gamma_f = 152.78 \text{ lb/ft}^3$



D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	---	N/A	N/A	N/A	N/A
Strength reduction at the connection, CRu = Fyc / Fy	0.90	N/A	N/A	N/A	N/A

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

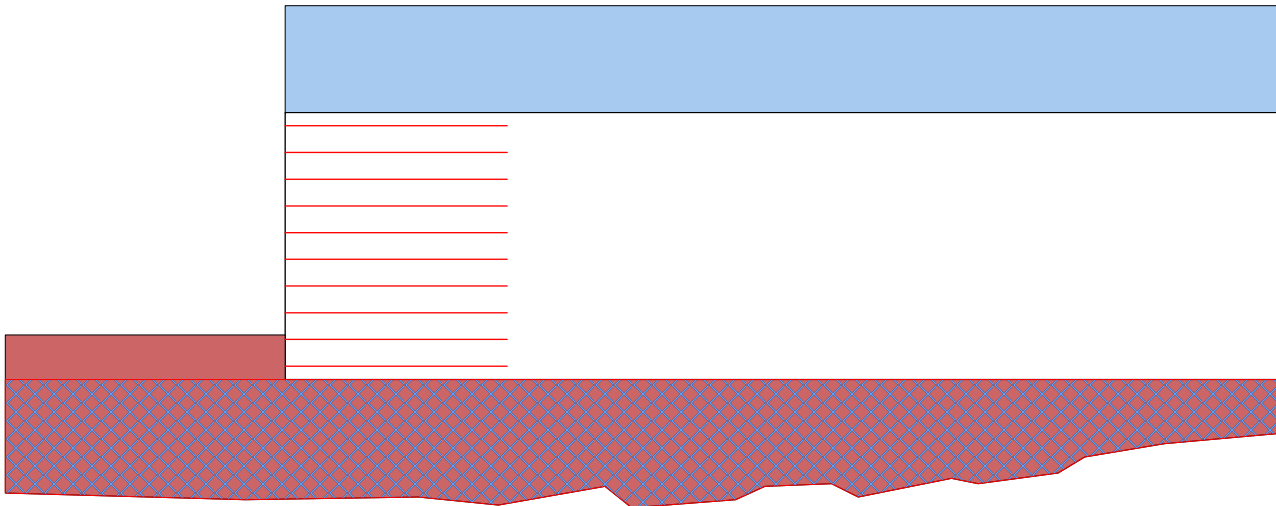
Design height, Hd	18.00	[ft]	{ Embedded depth is E = 3.00 ft, and height above top of finished bottom grade is H = 15.00 ft }
Batter, ω	0.0	[deg]	
Backslope, β	0.0	[deg]	
Backslope rise	0.0	[ft]	Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)

UNIFORM SURCHARGE

Uniformly distributed dead load is 1500.0 [lb/ft²], and live load is 250.0 [lb/ft²]

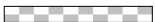
Hydrostatic water pressure exist in analysis. hw1 = 0.00 and hw2 = 0.00 ft.

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:	γ_{p-EV}	1.35	
Load factor for earthquake loads, EQ, from Table 3.4.1-1:	γ_{p-EQ}	1.00	
Load factor for live load surchrge, LS, from Figure C11.5.5-3(b): (Same as in External Stability).	γ_{p-LS}	1.75	
Load factor for dead load surchrge, ES: (Same as in External Stability).	γ_{p-ES}	1.50	
Resistance factor for reinforcement tension from Table 11.5.6-1: Metal Strips:	ϕ	Static 0.75	Combined static/seismic 1.00
Resistance factor for reinforcement tension in connectors from Table 11.5.6-1: Metal Strips:	ϕ	Static 0.75	Combined static/seismic 1.00
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 γ_{p-EV}	1.00	γ_{p-EQ} 1.00
Bearing Capacity γ_{p-EV}	1.35	γ_{p-EQ} 1.35
Load factor of active lateral earth pressure, EH, from Table 3.4.1-2 and Figure C11.5.5-2:	γ_{p-EH}	1.50
Load factor of active lateral earth pressure during earthquake (does not multiply P_{AE} and P_{IR}):	$(\gamma_{p-EH})_{EQ}$	1.50
Load factor for earthquake loads, EQ, from Table 3.4.1-1 (multiplies P_{AE} and P_{IR}):	γ_{p-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, $CDR = 0.97$, factored bearing load = 8274 lb/ft².

Foundation Interface: Direct sliding, CDR = 1.393, Eccentricity, $e/L = 0.2470$, CDR-overtopping = 2.02

M E T A L S T R I P				C O N N E C T I O N							
#	Elevation [ft]	Length [ft]	Type #	CDR [pullout resistance]	CDR [connection break]	CDR [metal strip strength]	Metal strip strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.90	15.00	1	N/A	1.17	1.30	1.305	0.542	1.438	0.2264	---
2	2.70	15.00	1	N/A	1.20	1.34	1.337	0.483	1.570	0.1874	---
3	4.50	15.00	1	N/A	1.25	1.38	1.384	0.430	1.733	0.1513	---
4	6.30	15.00	1	N/A	1.28	1.42	1.425	0.376	1.942	0.1184	---
5	8.10	15.00	1	N/A	1.32	1.46	1.464	0.323	2.221	0.0886	---
6	9.90	15.00	1	N/A	1.36	1.51	1.513	0.291	2.614	0.0624	---
7	11.70	15.00	1	N/A	1.42	1.58	1.583	0.277	3.220	0.0399	---
8	13.50	15.00	1	N/A	1.51	1.68	1.683	0.267	4.290	0.0217	---
9	15.30	15.00	1	N/A	1.62	1.80	1.797	0.255	6.747	0.0084	---
10	17.10	15.00	1	N/A	1.73	1.92	1.920	0.240	18.887	0.0010	---

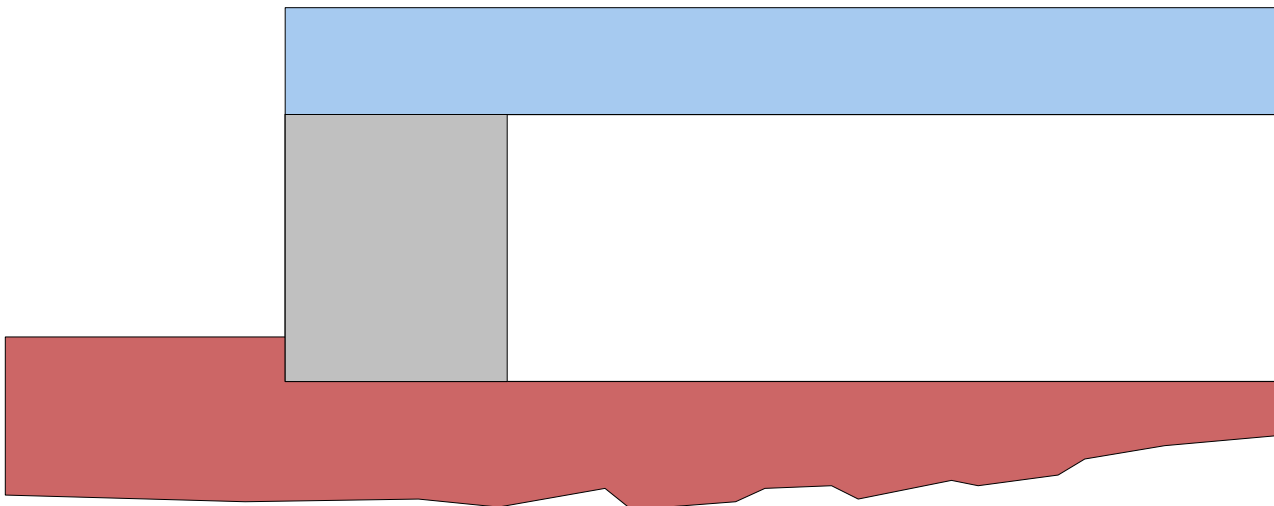
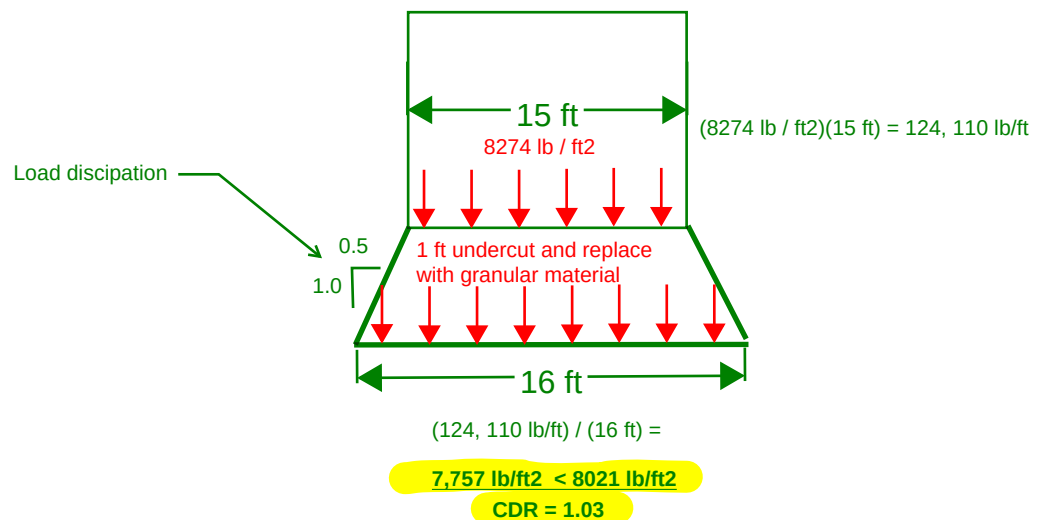
Geometries do not allow for 16 ft strap lengths. Undercutting and replacement will be necessary to improve bearing material and dissipate loading from MSE wall mass.

BEARING CAPACITY for GIVEN LAYOUT

	STATIC	SEISMIC	UNITS
(Water table is at wall base elevation)			
Factored bearing resistance, q-n	8021	N/A	[lb/ft ²]
Factored bearing load, σ_v	8273.6	N/A	[lb/ft ²]
Eccentricity, e	2.42	N/A	[ft]
Eccentricity, e/L	0.161	N/A	
CDR calculated	0.97	N/A	
Base length	15.00	N/A	[ft]

$$\text{Unfactored applied bearing pressure} = (\text{Unfactored R}) / [L - 2 * (\text{Unfactored } e)] =$$

Unfactored R = 58649.97 [lb/ft], L = 15.00, Unfactored e = 2.27 [ft], and Sigma = 5611.55 [lb/ft²]



SCALE:

0 2 4 6 8 10 [ft]



DIRECT SLIDING for GIVEN LAYOUT (for METAL STRIPS reinforcements)

Along reinforced and foundation soils interface: CDR-static = 1.393

#	Metal strip Elevation [ft]	Metal strip Length [ft]	CDR Static	CDR Seismic	Metal strip Type #	Product name
1	0.90	15.00	1.438	N/A	1	---
2	2.70	15.00	1.570	N/A	1	---
3	4.50	15.00	1.733	N/A	1	---
4	6.30	15.00	1.942	N/A	1	---
5	8.10	15.00	2.221	N/A	1	---
6	9.90	15.00	2.614	N/A	1	---
7	11.70	15.00	3.220	N/A	1	---
8	13.50	15.00	4.290	N/A	1	---
9	15.30	15.00	6.747	N/A	1	---
10	17.10	15.00	18.887	N/A	1	---

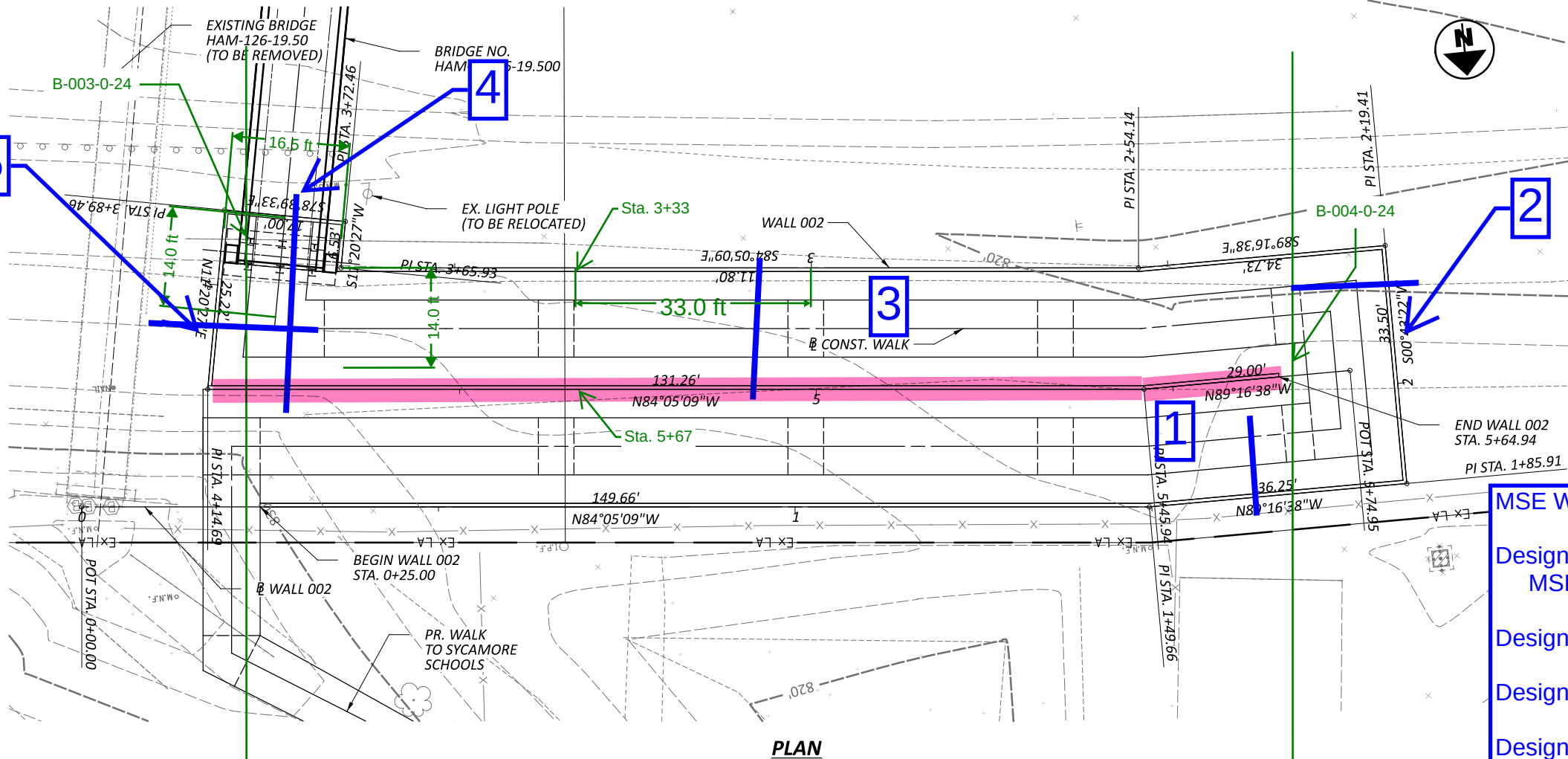
ECCENTRICITY for GIVEN LAYOUT (for Simplified Method)

At interface with foundation: e/L static = 0.2470; Overturning: CDR-static = 2.02

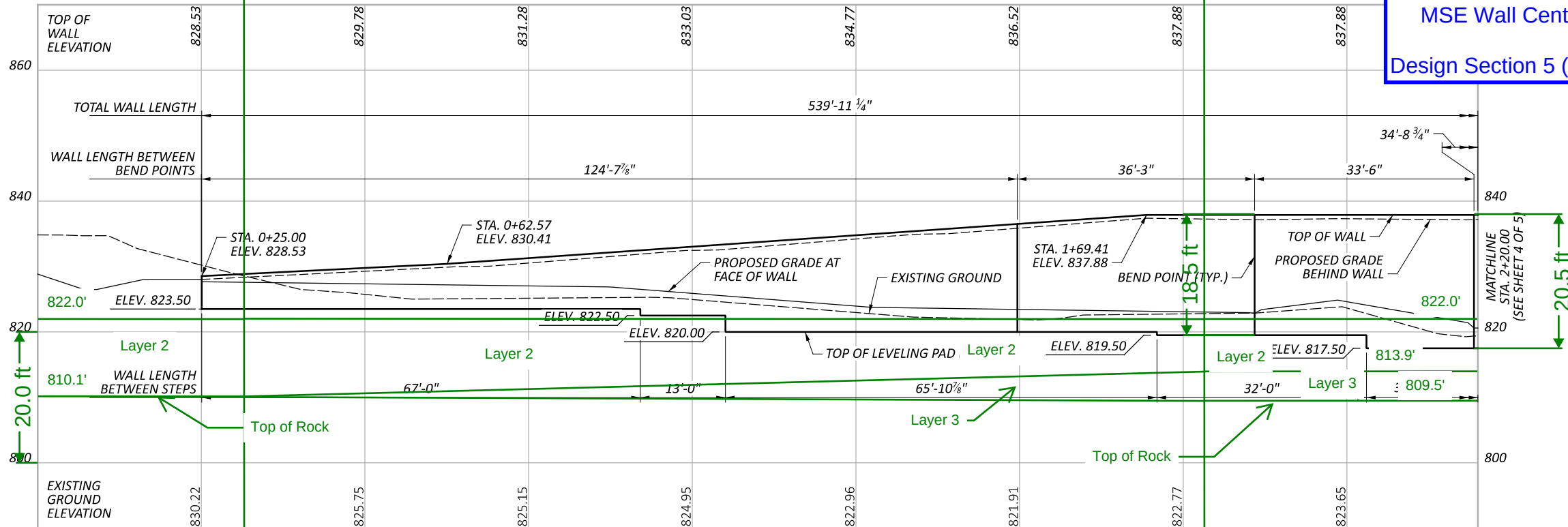
#	Metal strip Elevation [ft]	Metal strip Length [ft]	e / L Static	e / L Seismic	Metal strip Type #	Product name
1	0.90	15.00	0.2264	N/A	1	---
2	2.70	15.00	0.1874	N/A	1	---
3	4.50	15.00	0.1513	N/A	1	---
4	6.30	15.00	0.1184	N/A	1	---
5	8.10	15.00	0.0886	N/A	1	---
6	9.90	15.00	0.0624	N/A	1	---
7	11.70	15.00	0.0399	N/A	1	---
8	13.50	15.00	0.0217	N/A	1	---
9	15.30	15.00	0.0084	N/A	1	---
10	17.10	15.00	0.0010	N/A	1	---

Sta 5+82/Sta 8+83
18.5' Wall
(Ramp Crest)

Design Section 4



PLAN



ELEVATION (1 OF 3)

BENCHMARK DATA

BM T9 (MAGS)	STA. 264+09.05	ELEV. 821.779	OFFSET 58.74' LT.
BM SV2 (MAGS)	STA. 262+72.65	ELEV. 822.721	OFFSET 139.75' LT.

FOR ADDITIONAL BENCHMARK INFORMATION, SEE ROADWAY PLANS.

NOTES

1. EARTHWORK LIMITS SHOWN ARE APPROXIMATE. ACTUAL SLOPES SHALL CONFORM TO PLAN CROSS SECTIONS.

MSE Wall Design Sections:

Design Section 1

MSE Along Ramp Upslope of SR-126

Design Section 2 (MSE Wall at switch-back)

Design Section 3 Back to Back MSE Wall Upper Ramp

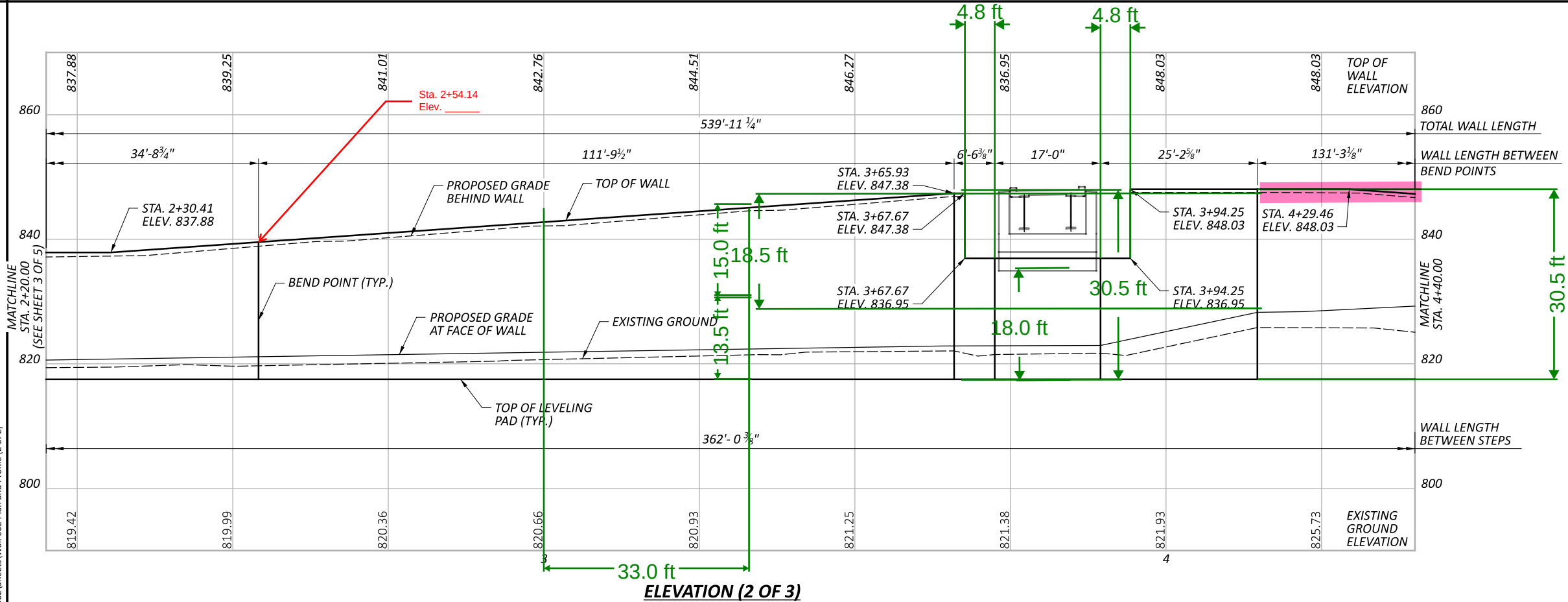
Design Section 4

MSE Wall Abutment

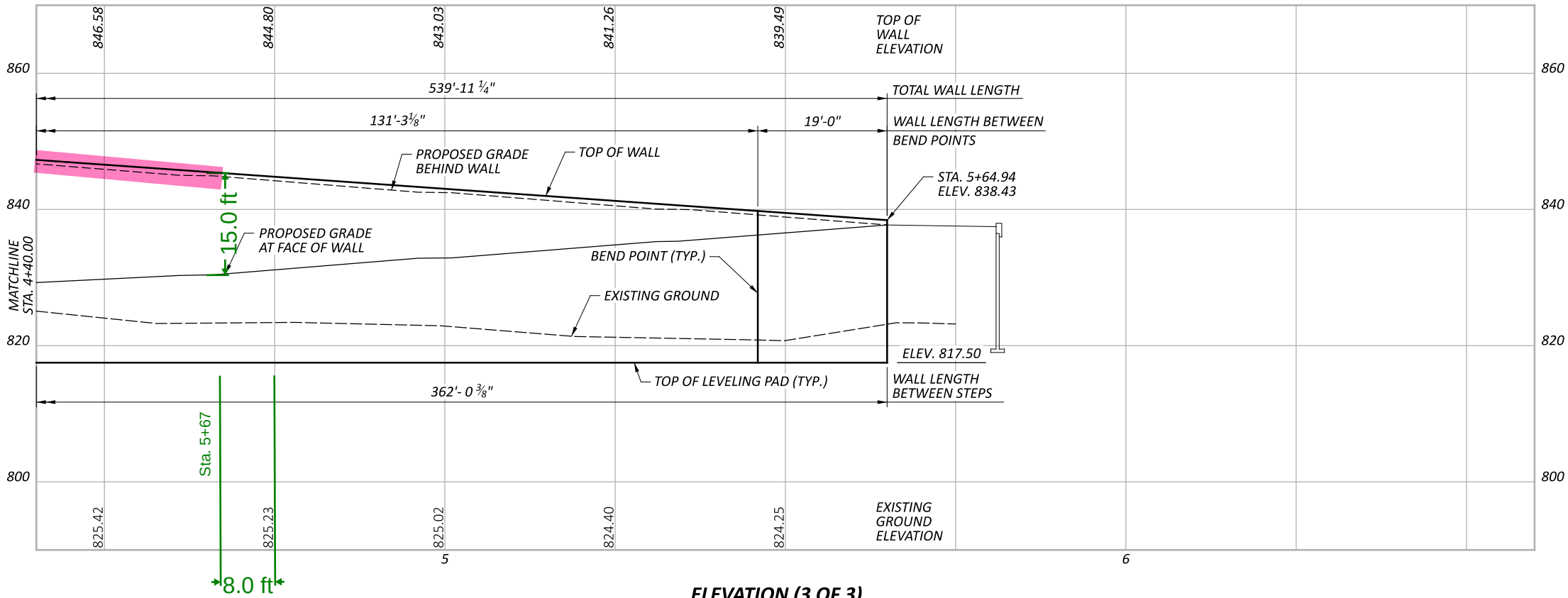
MSE Wall Back-to-Back Ramp walls

MSE Wall Center Height Back to Back Wall

Design Section 5 (MSE Wall - End Wall - Full Ramp Height)



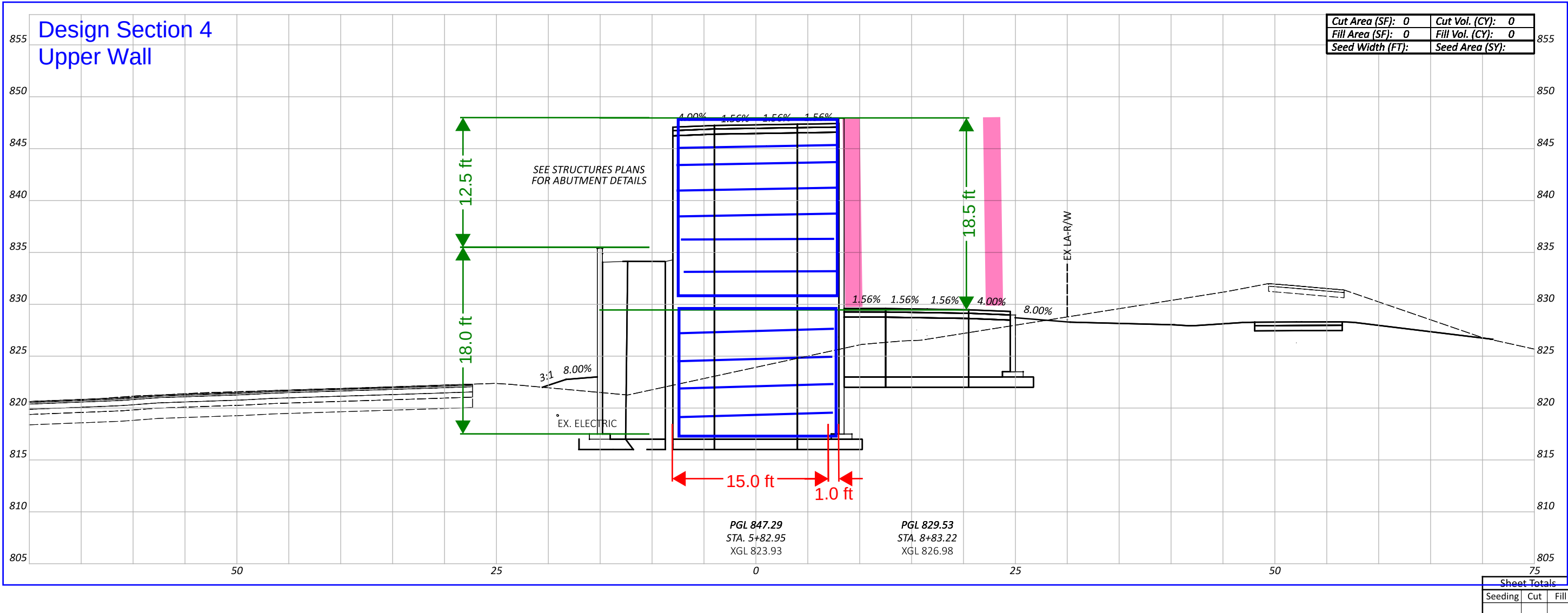
ELEVATION (2 OF 3)



ELEVATION (3 OF 3)

SFN	
N/A	
DESIGN AGENCY	
	
9999 CARVER ROAD SUITE 210 CINCINNATI, OH 45242 513.984.7500	
DESIGNER	CHECKER
RBK	XXX
REVIEWER	
XXX MM-DD-YY	
PROJECT ID	
114652	
SUBSET	TOTAL
4	5
SHEET	TOTAL
P.28	31

Forward Abutment Wall (North)



CROSS SECTIONS
STA. 5+82.95 AND STA. 8+83.22

MSEW(3.0): Update # 14.4

License number MSEW-302528

SOIL DATA

REINFORCED SOIL

Unit weight, γ	120.0 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	34.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{\text{equiv.}}$	120.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{\text{equiv.}}$	34.0°
Equivalent cohesion, $c_{\text{equiv.}}$	0.0 lb/ft ²

Water table is at wall base elevation

LATERAL EARTH PRESSURE COEFFICIENTS

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

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

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): $N_c = 42.16$ $N_\gamma = 41.06$

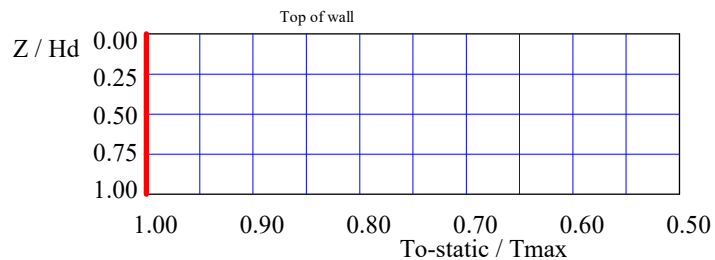
SEISMICITY

Not Applicable

INPUT DATA: Facia and Connection
(Analysis)

FACIA type: Segmental precast concrete panels.
Depth of panel is 0.50 ft. Horizontal distance to Center of Gravity of panel is 0.25 ft.
Average unit weight of panel is $\gamma_f = 152.78 \text{ lb/ft}^3$

Z / Hd	To-static / Tmax
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	---	N/A	N/A	N/A	N/A
Strength reduction at the connection, CRu = Fyc / Fy	0.90	N/A	N/A	N/A	N/A

AASHTO 2007-2010 (LRFD) Input Data

INTERNAL STABILITY

Load factor for vertical earth pressure, EV, from Table 3.4.1-2:	γ_{p-EV}	1.35	
Load factor for earthquake loads, EQ, from Table 3.4.1-1:	γ_{p-EQ}	1.00	
Load factor for live load surchrge, LS, from Figure C11.5.5-3(b): (Same as in External Stability).	γ_{p-LS}	1.75	
Load factor for dead load surchrge, ES: (Same as in External Stability).	γ_{p-ES}	1.50	
Resistance factor for reinforcement tension from Table 11.5.6-1: Metal Strips:	ϕ	Static 0.75	Combined static/seismic 1.00
Resistance factor for reinforcement tension in connectors from Table 11.5.6-1: Metal Strips:	ϕ	Static 0.75	Combined static/seismic 1.00
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 γ_{p-EV}	1.00	γ_{p-EQ} 1.00
Bearing Capacity γ_{p-EV}	1.35	γ_{p-EQ} 1.35
Load factor of active lateral earth pressure, EH, from Table 3.4.1-2 and Figure C11.5.5-2:	γ_{p-EH}	1.50
Load factor of active lateral earth pressure during earthquake (does not multiply P_{AE} and P_{IR}):	$(\gamma_{p-EH})_{EQ}$	1.50
Load factor for earthquake loads, EQ, from Table 3.4.1-1 (multiplies P_{AE} and P_{IR}):	γ_{p-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, $CDR = 1.60$, factored bearing load = 4629 lb/ft^2 .

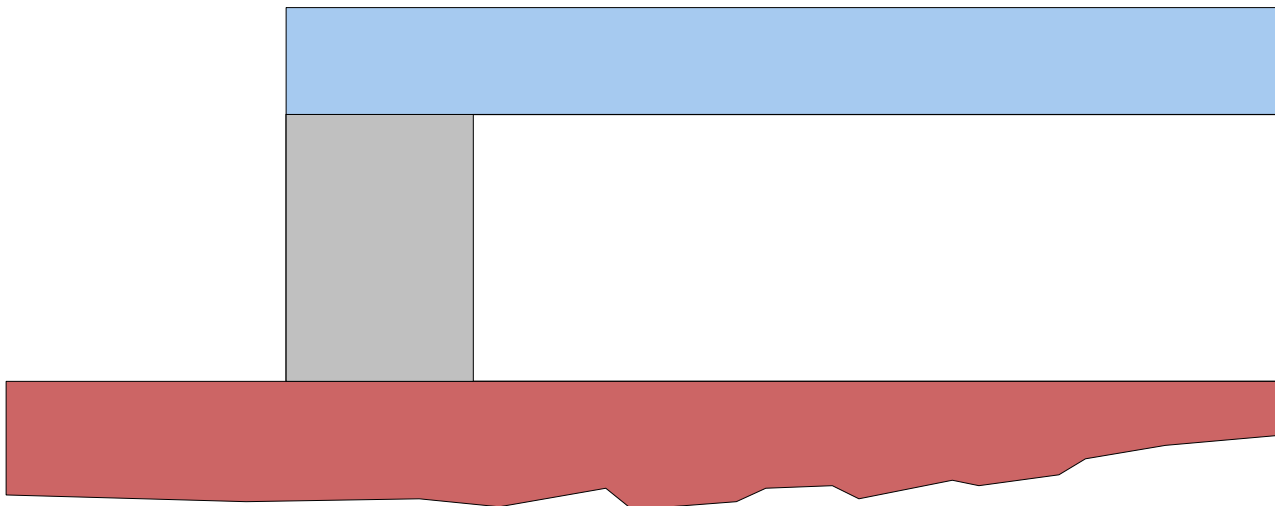
Foundation Interface: Direct sliding, CDR = 1.770, Eccentricity, $e/L = 0.1996$, CDR-overtopping = 2.51

M E T A L S T R I P				C O N N E C T I O N			Metal strip strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
#	Elevation [ft]	Length [ft]	Type #	CDR [pullout resistance]	CDR [connection break]	CDR [metal strip strength]					
1	1.00	13.00	1	N/A	1.78	1.98	1.976	1.007	1.849	0.1814	---
2	3.00	13.00	1	N/A	1.90	2.11	2.115	0.999	2.031	0.1477	---
3	5.00	13.00	1	N/A	2.08	2.31	2.313	0.966	2.252	0.1174	---
4	7.00	13.00	1	N/A	2.29	2.55	2.545	0.893	2.528	0.0904	---
5	9.00	13.00	1	N/A	2.56	2.84	2.839	0.787	2.880	0.0667	---
6	11.00	13.00	1	N/A	2.94	3.26	3.262	0.767	3.346	0.0464	---
7	13.00	13.00	1	N/A	3.54	3.94	3.937	0.739	3.991	0.0294	---
8	15.00	13.00	1	N/A	4.58	5.09	5.093	0.658	4.946	0.0158	---
9	17.00	13.00	1	N/A	5.58	6.20	6.199	0.369	6.501	0.0055	---

BEARING CAPACITY for GIVEN LAYOUT

	STATIC	SEISMIC	UNITS
(Water table is at wall base elevation)			
Factored bearing resistance, q-n	7409	N/A	[lb/ft ²]
Factored bearing load, σ_v	4628.5	N/A	[lb/ft ²]
Eccentricity, e	1.68	N/A	[ft]
Eccentricity, e/L	0.129	N/A	
CDR calculated	1.60	N/A	
Base length	13.00	N/A	[ft]

Unfactored applied bearing pressure = (Unfactored R) / [L - 2 * (Unfactored e)] =
Unfactored R = 32109.98 [lb/ft], L = 13.00, Unfactored e = 1.49 [ft], and Sigma = 3205.62 [lb/ft²]



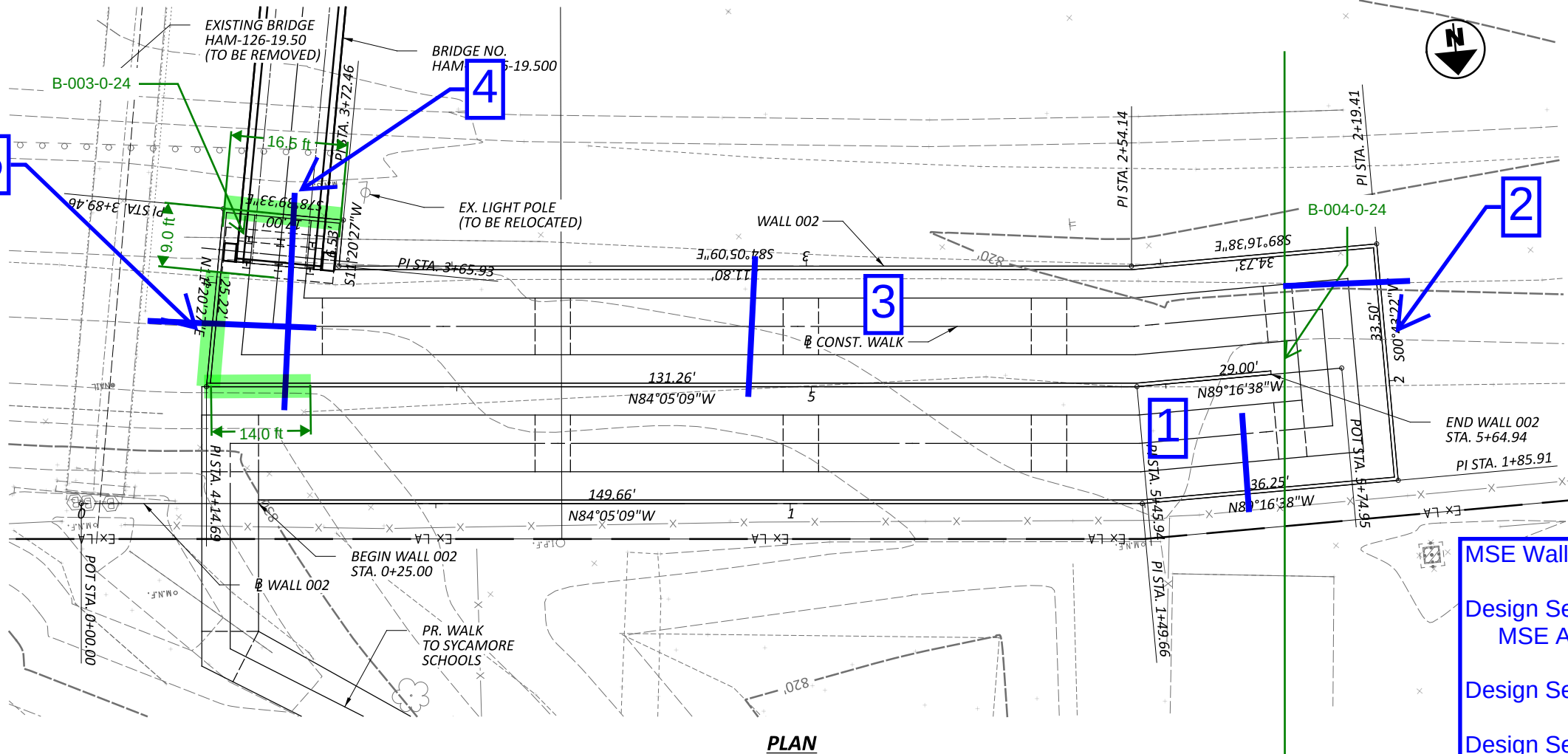
SCALE:

0 2 4 6 8 10 [ft]

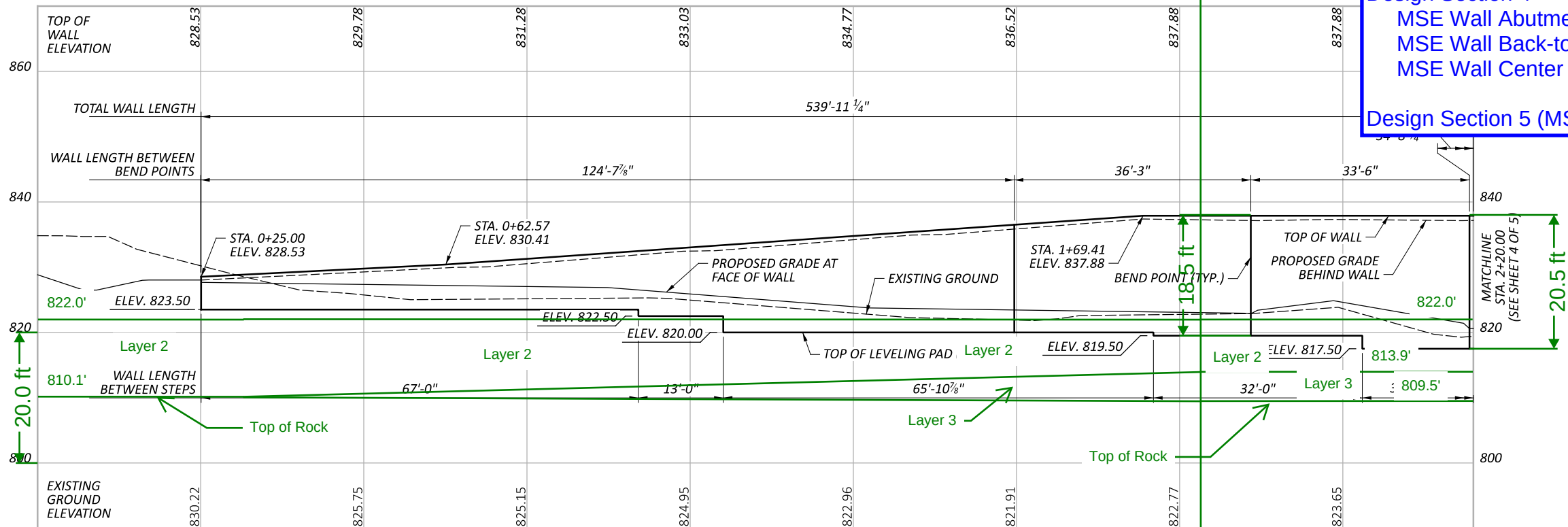


Sta 5+82/Sta 8+83
30.5' Wall

Design Section 5



PLAN



ELEVATION (1 OF 3)

BENCHMARK DATA

BM T9 (MAGS)	STA. 264+09.05	ELEV. 821.779	OFFSET 58.74' LT.
BM SV2 (MAGS)	STA. 262+72.65	ELEV. 822.721	OFFSET 139.75' LT.

FOR ADDITIONAL BENCHMARK INFORMATION, SEE ROADWAY PLANS.

NOTES

1. EARTHWORK LIMITS SHOWN ARE APPROXIMATE. ACTUAL SLOPES SHALL CONFORM TO PLAN CROSS SECTIONS.

MSE Wall Design Sections:

Design Section 1

MSE Along Ramp Upslope of SR-126

Design Section 2 (MSE Wall at switch-back)

Design Section 3 Back to Back MSE Wall Upper Ramp

Design Section 4

MSE Wall Abutment

MSE Wall Back-to-Back Ramp walls

MSE Wall Center Height Back to Back Wall

Design Section 5 (MSE Wall - End Wall - Full Ramp Height)

WALL PLAN AND ELEVATION (1 OF 2)

WALL 002

ALONG NORTH APPROACH

SFN

N/A

DESIGN AGENCY



9999 CARVER ROAD
SUITE 210
CINCINNATI, OH 45242
513.984.7500

DESIGNER
RBK

CHECKER
XXX

REVIEWER

XXX MM-DD-YY

PROJECT ID

114652

SUBSET

3

TOTAL

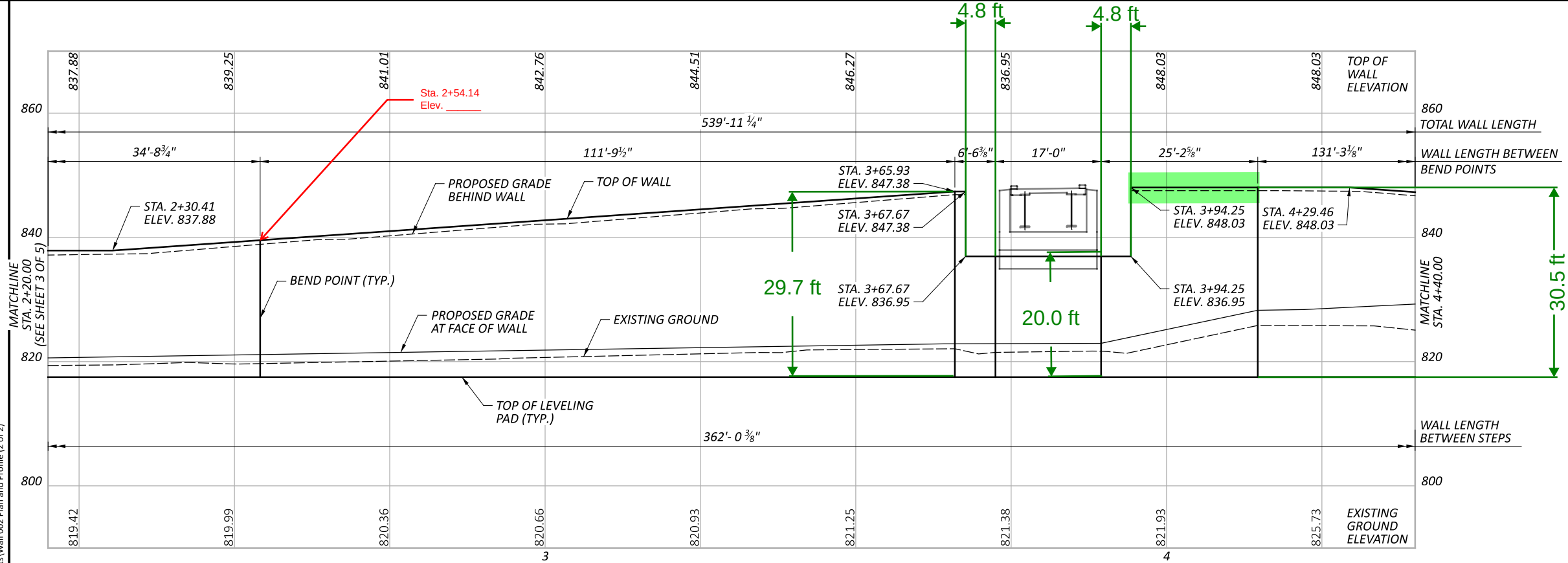
5

SHEET

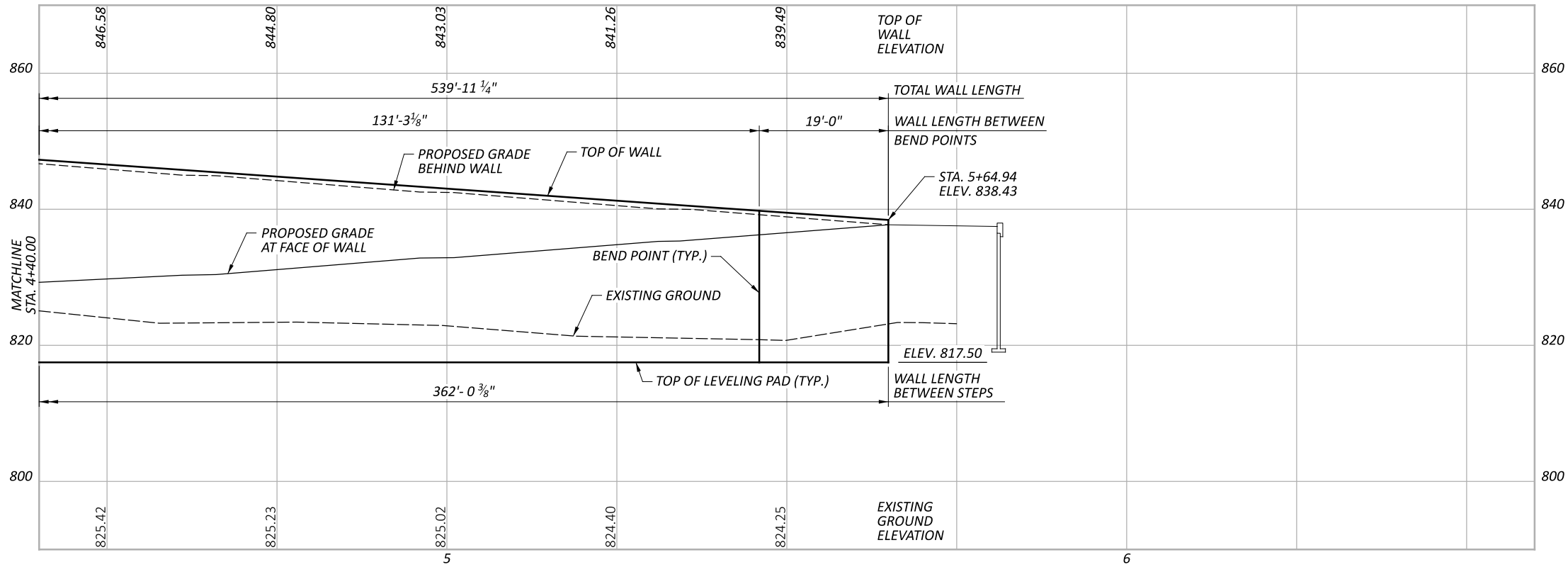
P.27

TOTAL

32



ELEVATION (2 OF 3)

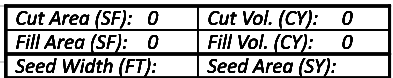


ELEVATION (3 OF 3)

WALL PLAN AND ELEVATION (2 OF 2)
WALL 002
ALONG NORTH APPROACH

SFN	N/A
DESIGN AGENCY	HDR 9999 CARVER ROAD SUITE 210 CINCINNATI, OH 45242 513.984.7500
DESIGNER	CHECKER
RBK	XXX
REVIEWER	XXX MM-DD-YY
PROJECT ID	114652
SUBSET	TOTAL
4	5
SHEET	TOTAL
P.28	31

Design Section 5			
End of Wall			



Sheet Totals		
Seeding	Cut	F

HDR

DESIGNER
MJL

REVIEWER
XXX MM-DD-YY

PROJECT ID
114652

SHEET	TOTAL
P.19	32

CROSS SECTIONS
STA. 5+82.95 AND STA. 8+83.22

MSEW(3.0): Update # 14.4

License number MSEW-302528

SOIL DATA

REINFORCED SOIL

Unit weight, γ	120.0 lb/ft ³
Design value of internal angle of friction, ϕ	34.0 °

RETAINED SOIL

Unit weight, γ 120.0 lb/ft³
Design value of internal angle of friction, ϕ 34.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{\text{equiv.}}$	130.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{\text{equiv.}}$	0.0 °
Equivalent cohesion, $c_{\text{equiv.}}$	2400.0 lb/ft ²

Water table is at wall base elevation

LATERAL EARTH PRESSURE COEFFICIENTS

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

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

BEARING CAPACITY

Bearing capacity coefficients (calculated by MSEW): $N_c = 5.14$ $N_\gamma = 0.00$

SEISMICITY

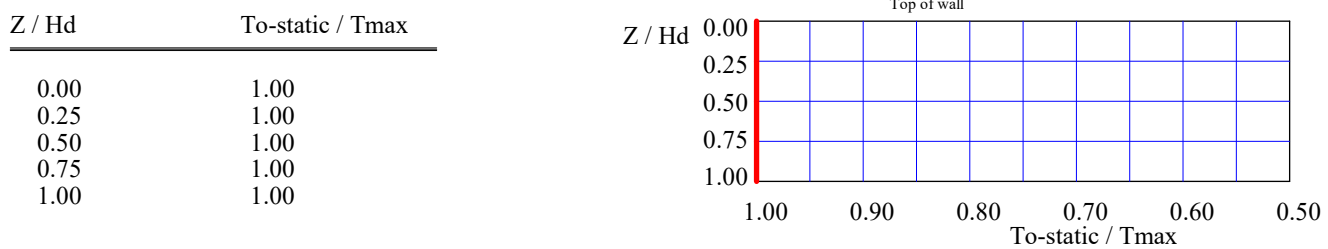
Not Applicable

34*

Retained is the same as Reinforced given - the location of the wall at the end of two back to back MSE walls.

INPUT DATA: Facia and Connection (Analysis)

FACIA type: Segmental precast concrete panels.
 Depth of panel is 0.50 ft. Horizontal distance to Center of Gravity of panel is 0.25 ft.
 Average unit weight of panel is $\gamma_f = 152.78 \text{ lb/ft}^3$



D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	---	N/A	N/A	N/A	N/A
Strength reduction at the connection, CRu = Fyc / Fy	0.90	N/A	N/A	N/A	N/A

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

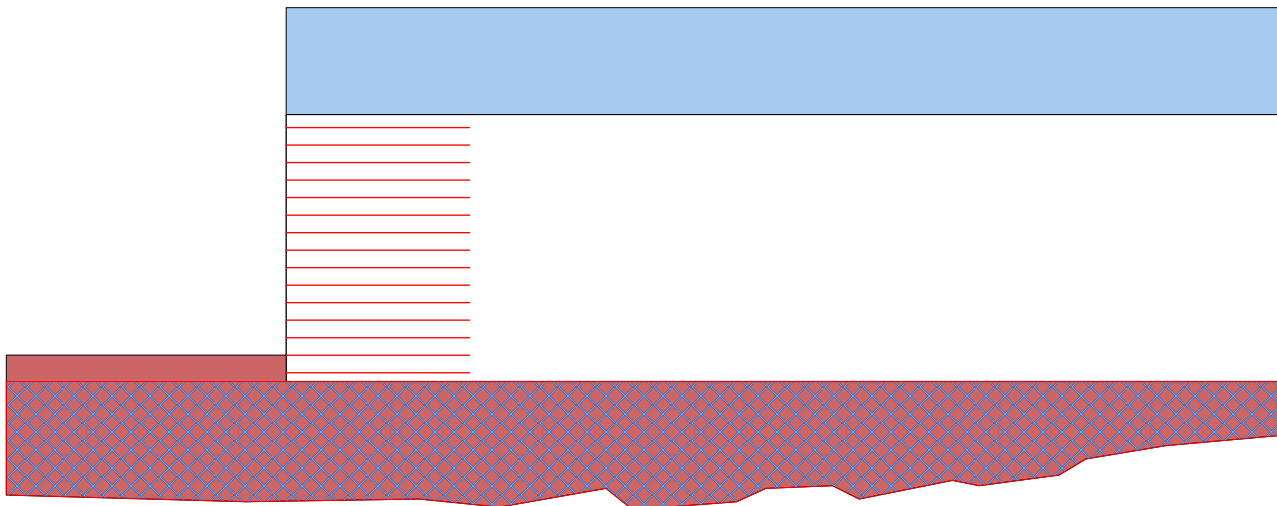
Design height, Hd	30.50	[ft]	{ Embedded depth is E = 3.00 ft, and height above top of finished bottom grade is H = 27.50 ft }
Batter, ω	0.0	[deg]	
Backslope, β	0.0	[deg]	
Backslope rise	0.0	[ft]	Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)

UNIFORM SURCHARGE

Uniformly distributed dead load is 0.0 [lb/ft²], and live load is 250.0 [lb/ft²]

Hydrostatic water pressure exist in analysis. hw1 = 0.00 and hw2 = 0.00 ft.

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:	γ_{p-EV}	1.35	
Load factor for earthquake loads, EQ, from Table 3.4.1-1:	γ_{p-EQ}	1.00	
Load factor for live load surchrge, LS, from Figure C11.5.5-3(b): (Same as in External Stability).	γ_{p-LS}	1.75	
Load factor for dead load surchrge, ES: (Same as in External Stability).	γ_{p-ES}	1.50	
Resistance factor for reinforcement tension from Table 11.5.6-1: Metal Strips:	ϕ	Static 0.75	Combined static/seismic 1.00
Resistance factor for reinforcement tension in connectors from Table 11.5.6-1: Metal Strips:	ϕ	Static 0.75	Combined static/seismic 1.00
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 γ_{p-EV}	1.00	γ_{p-EQ} 1.00
Bearing Capacity γ_{p-EV}	1.35	γ_{p-EQ} 1.35
Load factor of active lateral earth pressure, EH, from Table 3.4.1-2 and Figure C11.5.5-2:	γ_{p-EH}	1.50
Load factor of active lateral earth pressure during earthquake (does not multiply P_{AE} and P_{IR}):	$(\gamma_{p-EH})_{EQ}$	1.50
Load factor for earthquake loads, EQ, from Table 3.4.1-1 (multiplies P_{AE} and P_{IR}):	γ_{p-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

MSEW -- Mechanically Stabilized Earth Walls

MSEW -- Mechanically Stabilized Earth Walls

Present Date/Time: Tue Jun 17 09:59:24 2025

C:\.....ocuments\MSEW_Darren\HAM-126\20250616_HAM-126-19.50_NorthAbutment_Sta582-883_30.5'wall.BEN HAM-126-19.50

MSEW -- Mechanically Stabilized Earth Walls

MSEW -- Mechanically Stabilized Earth Walls



MSEW -- Mechanically Stabilized Earth Walls

MSEW -- Mechanically Stabilized Earth Walls



DIRECT SLIDING for GIVEN LAYOUT (for METAL STRIPS reinforcements)

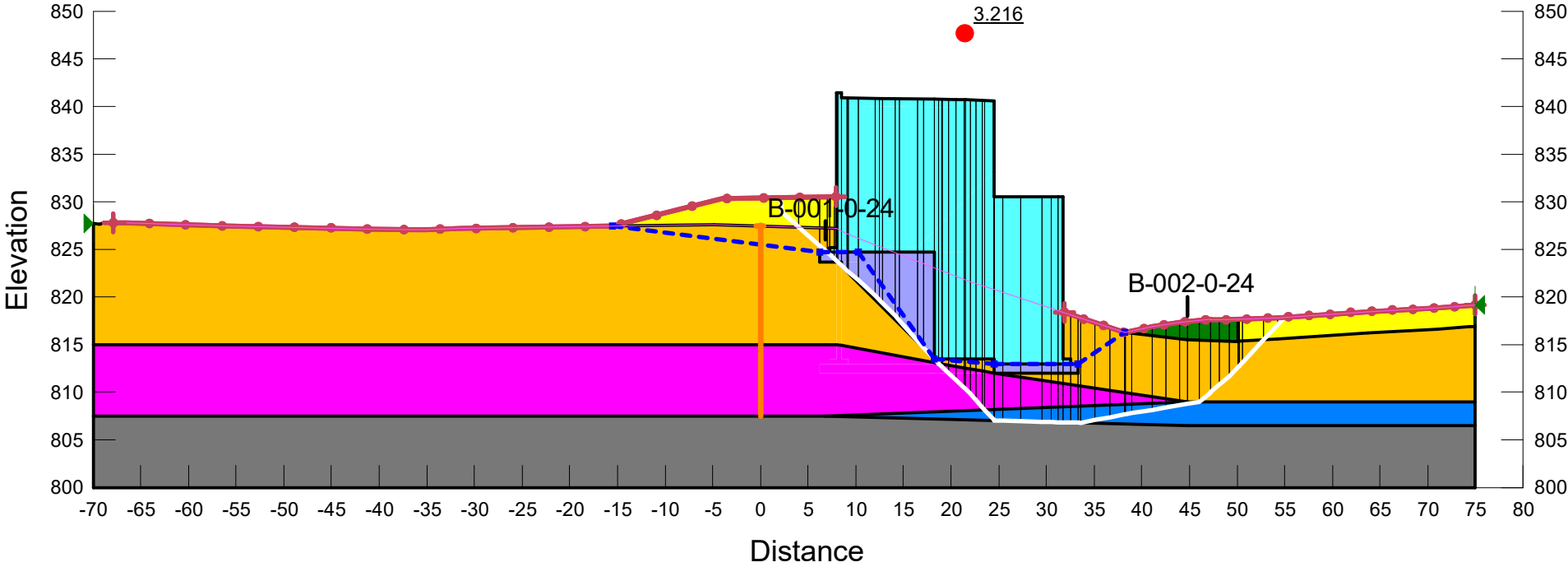
Along reinforced and foundation soils interface: CDR-static = 1.837

#	Metal strip Elevation [ft]	Metal strip Length [ft]	CDR Static	CDR Seismic	Metal strip Type #	Product name
1	1.00	21.00	1.935	N/A	1	---
2	3.00	21.00	2.054	N/A	1	---
3	5.00	21.00	2.189	N/A	1	---
4	7.00	21.00	2.344	N/A	1	---
5	9.00	21.00	2.522	N/A	1	---
6	11.00	21.00	2.731	N/A	1	---
7	13.00	21.00	2.987	N/A	1	---
8	15.00	21.00	3.281	N/A	1	---
9	17.00	21.00	3.638	N/A	1	---
10	19.00	21.00	4.083	N/A	1	---
11	21.00	21.00	4.652	N/A	1	---
12	23.00	21.00	5.404	N/A	1	---
13	25.00	21.00	6.447	N/A	1	---
14	27.00	21.00	7.990	N/A	1	---
15	29.00	21.00	10.502	N/A	1	---

Slope Stability Analyses

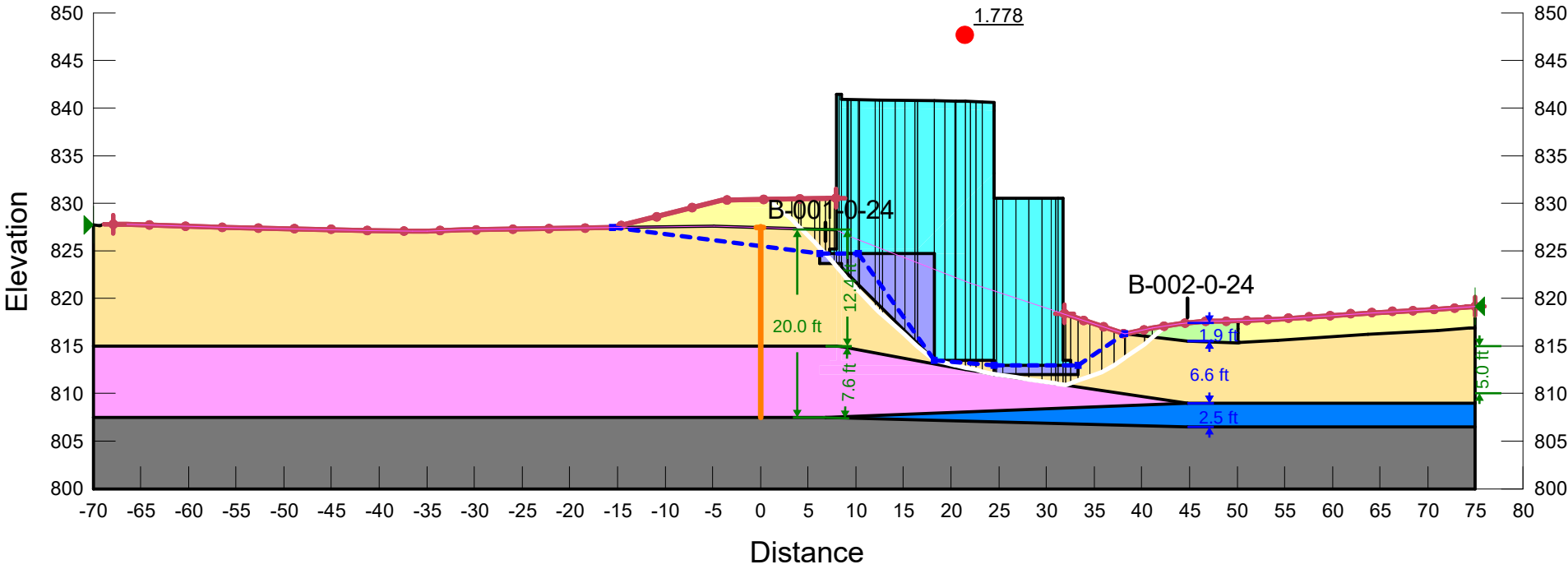
Name: 2+04_Short Term
Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Description: Left To Right
Optimize Critical Slip Surface Location: Yes

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Piezometric Surface
	Bedrock				1
	High Strength	120			1
	Item 203 Embankment Fill (ST)	125	2,000	0	1
	Layer 1- Medium Stiff Cohesive (ST)	110	750	0	1
	Layer 2- Very Stiff Cohesive (ST)	130	2,400	0	1
	Layer 3- Hard Cohesive (ST)	130	4,000	0	1
	Layer 4- Dense Granular	120	0	37	1
	Retained Soil	120	0	30	1



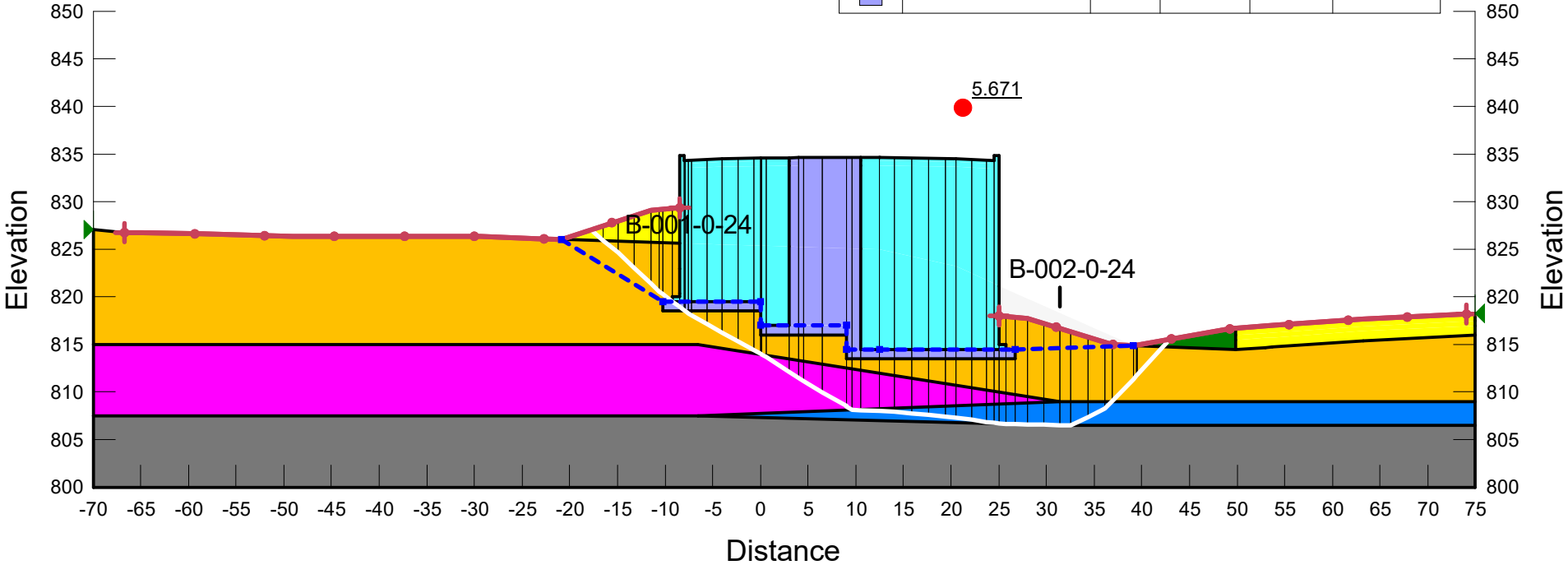
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Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Description: Left To Right

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Piezometric Surface
	Bedrock				1
	High Strength	120			1
	Item 203 Embankment Fill (LT)	125	200	26	1
	Layer 1- Medium Stiff Cohesive (LT)	110	90	22	1
	Layer 2- Very Stiff Cohesive (LT)	130	250	25	1
	Layer 3- Hard Cohesive (LT)	130	440	28	1
	Layer 4- Dense Granular	120	0	37	1
	Retained Soil	120	0	30	1



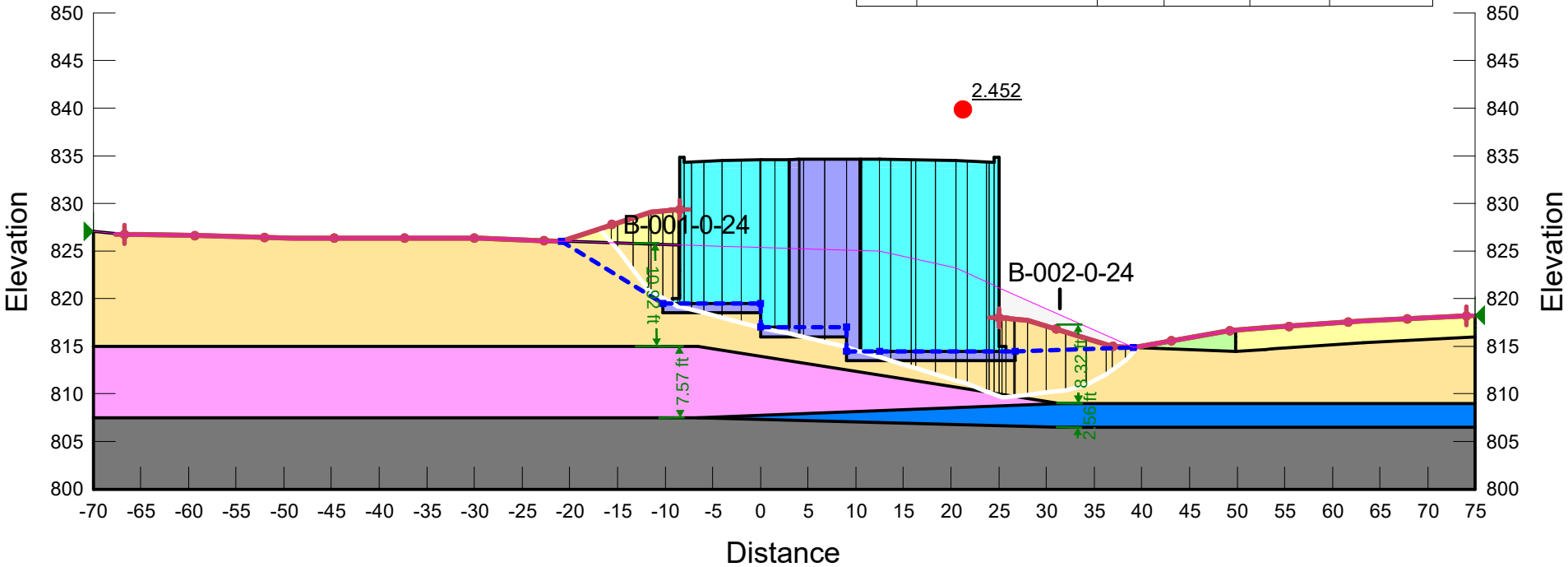
Name: 2+93_Short Term (2)
Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Description: Left To Right
Optimize Critical Slip Surface Location: Yes

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Piezometric Surface
	Bedrock				1
	High Strength	120			1
	Item 203 Embankment Fill (ST)	125	2,000	0	1
	Layer 1- Medium Stiff Cohesive (ST)	110	750	0	1
	Layer 2- Very Stiff Cohesive (ST)	130	2,400	0	1
	Layer 3- Hard Cohesive (ST)	130	4,000	0	1
	Layer 4- Dense Granular	120	0	37	1
	Retained Soil	120	0	30	1



Name: 2+93_Long Term (2)
Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Description: Left To Right
Optimize Critical Slip Surface Location: Yes

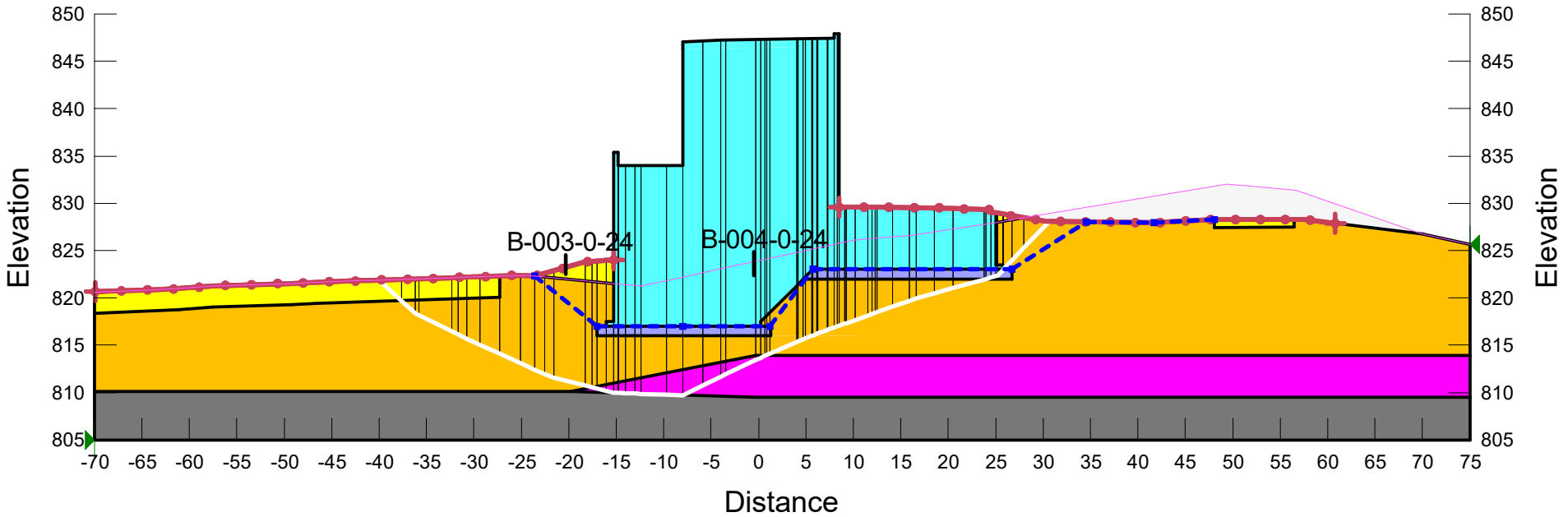
Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Piezometric Surface
	Bedrock				1
	High Strength	120			1
	Item 203 Embankment Fill (LT)	125	200	26	1
	Layer 1- Medium Stiff Cohesive (LT)	110	90	22	1
	Layer 2- Very Stiff Cohesive (LT)	130	250	25	1
	Layer 3- Hard Cohesive (LT)	130	440	28	1
	Layer 4- Dense Granular	120	0	37	1
	Retained Soil	120	0	30	1



Name: 5+82_Short Term (2)
Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Description: Right To Left
Optimize Critical Slip Surface Location: Yes

8.315

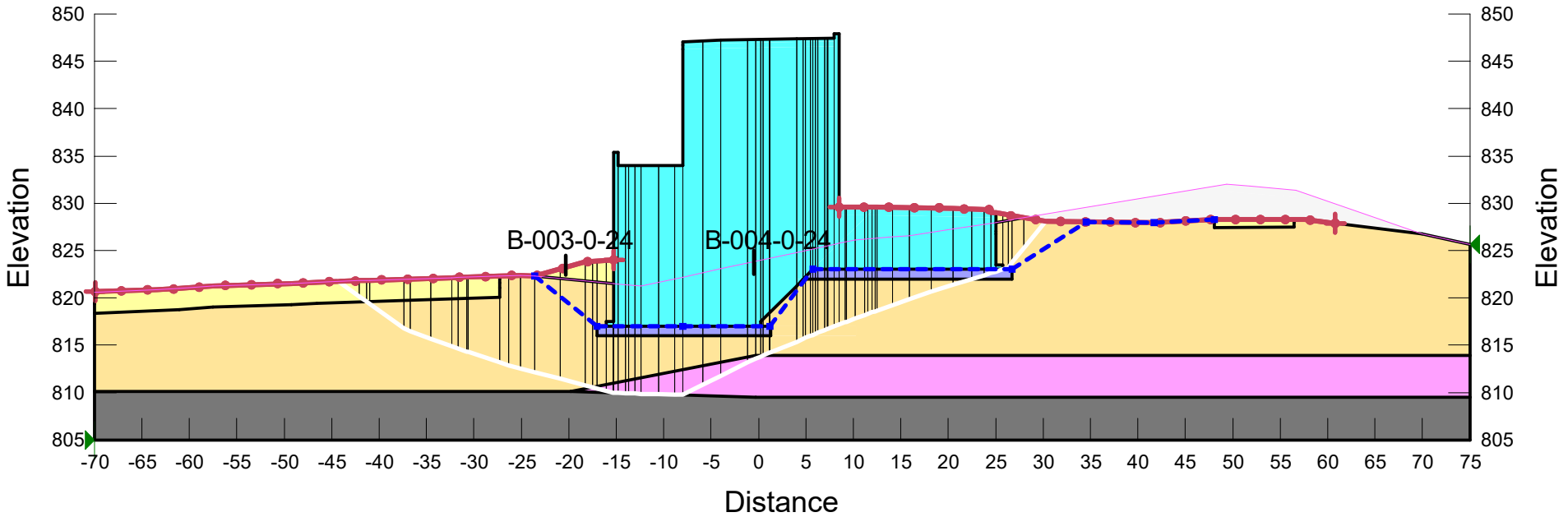
Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Piezometric Surface
	Bedrock				1
	High Strength	120			1
	Item 203 Embankment Fill (ST)	125	2,000	0	1
	Layer 2- Very Stiff Cohesive (ST)	130	2,400	0	1
	Layer 3- Hard Cohesive (ST)	130	4,000	0	1
	Retained Soil	120	0	30	1



Name: 5+82_Long Term (2)
Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Description: Right To Left
Optimize Critical Slip Surface Location: Yes

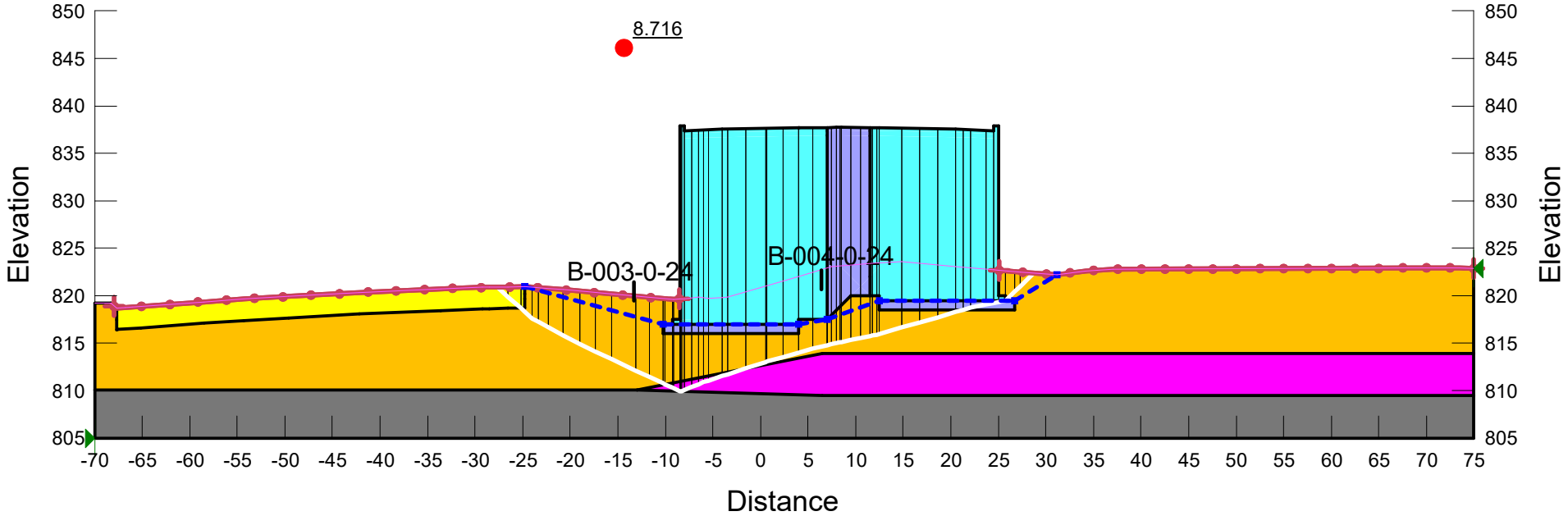
3.457

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Piezometric Surface
	Bedrock				1
	High Strength	120			1
	Item 203 Embankment Fill (LT)	125	200	26	1
	Layer 2- Very Stiff Cohesive (LT)	130	250	25	1
	Layer 3- Hard Cohesive (LT)	130	440	28	1
	Retained Soil	120	0	30	1



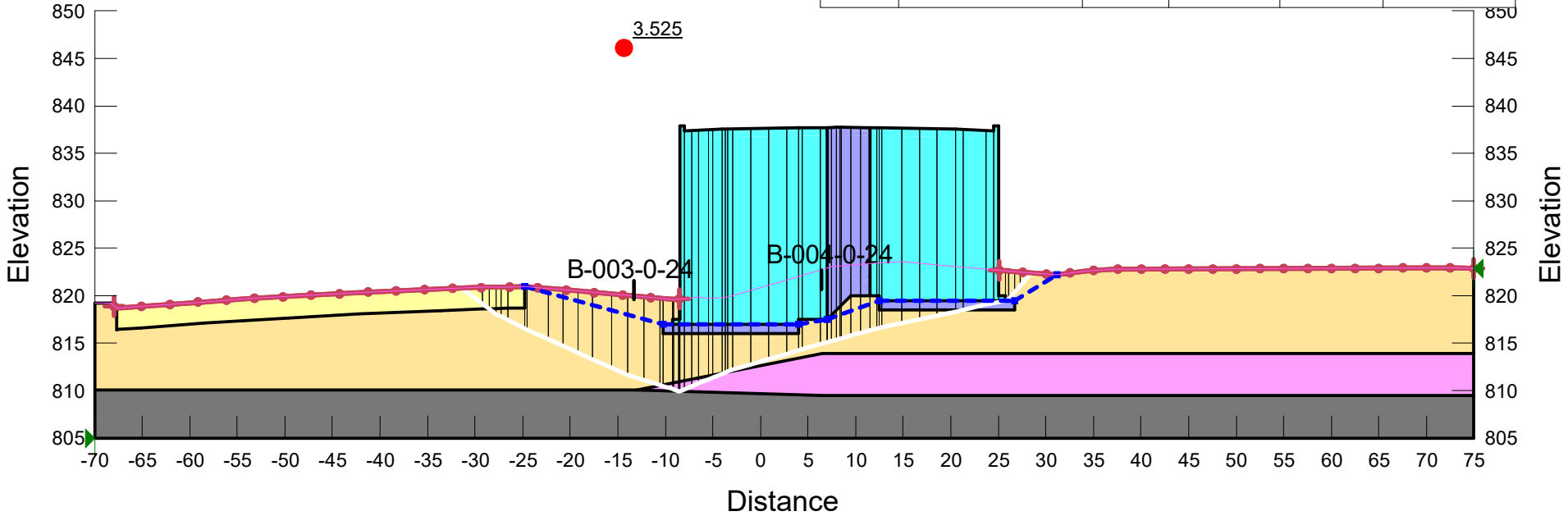
Name: 7+16_Short Term (2)
Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Description: Right To Left
Optimize Critical Slip Surface Location: Yes

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Piezometric Surface
	Bedrock				1
	High Strength	120			1
	Item 203 Embankment Fill (ST)	125	2,000	0	1
	Layer 2- Very Stiff Cohesive (ST)	130	2,400	0	1
	Layer 3- Hard Cohesive (ST)	130	4,000	0	1
	Retained Soil	120	0	30	1



Name: 7+16_Long Term (2)
Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Description: Right To Left
Optimize Critical Slip Surface Location: Yes

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Piezometric Surface
	Bedrock				1
	High Strength	120			1
	Item 203 Embankment Fill (LT)	125	200	26	1
	Layer 2- Very Stiff Cohesive (LT)	130	250	25	1
	Layer 3- Hard Cohesive (LT)	130	440	28	1
	Retained Soil	120	0	30	1



Settlement Analyses

Client ODOT
Project HAM-126-19.50
Task Settlement Analyses Summary

Calculated: DCM
Checked: MM
Revised: DCM

Date: 12/29/2024
Date: 1/6/2025
Date: 6/17/2025

Station	Offset	Consolidation Settlement (in.) ¹	Time (Month) to	
			50%	90%
2+04	CL	0.59	2	19
2+04	8.5 RT	0.78	2	16
2+04	25 RT	0.23	1	5
2+93	8.5 LT	0.29	0.5	9
2+93	7.5 RT	0.30	0.5	5
2+93	25 RT	0.29	1	5
5+82	2 LT	0.18	0.2	3
5+82	8.5 RT	0.78	1	10
5+82	25 RT	0.05	1	10
7+16	8 LT	0.39	0.5	2
7+16	9.5 RT	0.79	1	7
7+16	25 RT	0.41	0.5	6

Station	Offset	Consolidation Settlement (in.) ¹	Station	Offset	Consolidation Settlement (in.) ¹	Wall	Differential Settlement	
						Section Length (ft)	(in.)	(in. / ft of wall)
Sta. 2+04	CL	0.59	Sta. 2+93	8.5 LT	0.29	89	0.3	3/1000
Sta. 2+04	8.5 RT	0.78	Sta. 2+93	7.5 RT	0.30	89	0.5	5/1000
Sta. 2+04	25 RT	0.23	Sta. 2+93	25 RT	0.29	89	0.1	1/1000
Sta. 5+82	2 LT	0.18	Sta. 7+16	8 LT	0.39	134	0.2	2/1000
Sta. 5+82	8.5 RT	0.78	Sta. 7+16	9.5 RT	0.79	134	0.0	0/1000
Sta. 5+82	25 RT	0.05	Sta. 7+16	25 RT	0.41	134	0.4	3/1000

1. Measured from top of MSE wall leveling pad to top of bedrock.

Settlement Parameter Determination

Layer	Undrained Shear Strength (Su) (psf)						Moist Unit Wt. (pcf)		Total Unit Wt. (pcf)		Adopted Short Term Parameters	Long-Term Strength Values						Adopted Long Term Strength Parameters	Consolidation Values								Adopted Consolidation Parameters
	PPR	N-values				Tested						Correlation	Tested	Correlation	Tested	N ₆₀ Value	N ₁₆₀ Value		ODOT GDM Correlations		Tested		Correlated Values			Laboratory Tested Values	
		GDM	Sowers	T and P	Values		Cohesion (psf)	phi (deg)	Cohesion (psf)	phi (deg)									e _o	C _c	C _r = 0.2C _c	e _o	C _c	C _r	P _c		
Layer 1 MEDIUM STIFF COHESIVE	Max	500	875	1225	931		108		118		S _u = 750 psf Φ = 0 deg Y _{moist} = 110 pcf Y _{total} = 120 pcf	Max	7	14	88	22		c' = 90 psf Φ' = 22 deg Y _{moist} = 110 pcf Y _{total} = 120 pcf	Max	0.888	0.243	0.049	N/A	N/A	N/A	N/A	e _o = 0.888 C _c = 0.243 C _r = 0.049 P _c = 5500 psf
	Min	500	875	1225	931		108		118			Min	7	14	88	22			Min	0.888	0.243	0.049	N/A	N/A	N/A	N/A	
	Average	500	875	1225	931		108		118			Average	7	14	88	22			Average	0.888	0.243	0.049	N/A	N/A	N/A	N/A	
	Std Dev	N/A	N/A	N/A	N/A		N/A		N/A			Std Dev	N/A	N/A	N/A	N/A			Std Dev	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	Avg + Std	N/A	N/A	N/A	N/A		N/A		N/A			Avg + Std	N/A	N/A	N/A	N/A			Avg + Std	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	Avg - Std	N/A	N/A	N/A	N/A		N/A		N/A			Avg - Std	N/A	N/A	N/A	N/A			Avg - Std	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Layer 2 VERY STIFF COHESIVE	Max	4500	3875	4000	4000	2538	118	132	128		S _u = 2400 psf Φ = 0 deg Y _{moist} = 130 pcf Y _{total} = 140 pcf	Max	31	48	303	26		c' = 250 psf Φ' = 25 deg Y _{moist} = 130 pcf Y _{total} = 140 pcf	Max	0.772	0.414	0.083	0.628	0.122	0.022	6000	e _o = 0.580 C _c = 0.113 C _r = 0.022 P _c = 5500 psf
	Min	2500	1875	3750	1995	2228	112	129	122			Min	15	22	188	24			Min	0.570	0.198	0.040	0.531	0.104	0.021	5000	
	Average	4154	2900	3975	3073	2383	115	130	125			Average	23	35	250	25			Average	0.665	0.338	0.068	0.580	0.113	0.022	5500	
	Std Dev	658	775	79	808	220	3	2	3			Std Dev	6	8	44	1			Std Dev	0.069	0.068	0.014	0.069	0.013	0.001	707	
	Avg + Std	4812	3675	4054	3881	2602	118	132	128			Avg + Std	29	43	293	26			Avg + Std	0.734	0.405	0.081	0.648	0.126	0.022	6207	
	Avg - Std	3496	2125	3896	2266	2163	112	129	122			Avg - Std	17	26	206	24			Avg - Std	0.596	0.270	0.054	0.511	0.100	0.021	4793	
Layer 3 HARD COHESIVE	Max	4500	10754	4000	4000		130		140		S _u = 4000 psf Φ = 0 deg Y _{moist} = 130 pcf Y _{total} = 140 pcf	Max	93	105	609	28		c' = 440 psf Φ' = 28 deg Y _{moist} = 130 pcf Y _{total} = 140 pcf	Max	0.699	0.261	0.052	N/A	N/A	N/A	N/A	e _o = 0.580 C _c = 0.113 C _r = 0.022 P _c = 5500 psf
	Min	3000	4875	4000	4000		120		130			Min	39	40	353	28			Min	0.400	0.207	0.041	N/A	N/A	N/A	N/A	
	Average	3800	6837	4000	4000		128		138			Average	58	67	441	28			Average	0.489	0.227	0.045	N/A	N/A	N/A	N/A	
	Std Dev	570	2270	0	0		4		4			Std Dev	21	24	98	0			Std Dev	0.109	0.026	0.005	N/A	N/A	N/A	N/A	
	Avg + Std	4370	9107	4000	4000		132		142			Avg + Std	79	91	539	28			Avg + Std	0.598	0.253	0.051	N/A	N/A	N/A	N/A	
	Avg - Std	3230	4566	4000	4000		123		133			Avg - Std	37	43	343	28			Avg - Std	0.381	0.201	0.040	N/A	N/A	N/A	N/A	
Layer 4 DENSE GRANULAR	Max	N/A	N/A	N/A	N/A		122		132		S _u = 0 psf Φ = 37 deg Y _{moist} = 120 pcf Y _{total} = 130 pcf	Max	48	57	N/A	43		c' = 0 psf Φ' = 37 deg Y _{moist} = 120 pcf Y _{total} = 130 pcf	Max	0.400	N/A	N/A	N/A	N/A	N/A	N/A	e _o = N/A C _c = N/A C _r = N/A P _c = N/A psf
	Min	N/A	N/A	N/A	N/A		122		132			Min	48	57	N/A	43			Min	0.400	N/A	N/A	N/A	N/A	N/A	N/A	
	Average	N/A	N/A	N/A	N/A		122		132			Average	48	57	N/A	43			Average	0.400	N/A	N/A	N/A	N/A	N/A	N/A	
	Std Dev	N/A	N/A	N/A	N/A		N/A		N/A			Std Dev	N/A	N/A	N/A	N/A			Std Dev	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	Avg + Std	N/A	N/A	N/A	N/A		N/A		N/A			Avg + Std	N/A	N/A	N/A	N/A			Avg + Std	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	Avg - Std	N/A	N/A	N/A	N/A		N/A		N/A			Avg - Std	N/A	N/A	N/A	N/A			Avg - Std	N/A	N/A	N/A	N/A	N/A	N/A	N/A	

Note: Layer 4 capped at 37 degrees, as the sampler did not encounter refusal conditions.

Client: ODOT
Project: HAM-126-19.50
Task: Cv Values for Time Rate on Consolidation Analysis

Calculated: DCM
Checked: MM
Date: 12/29/2025
Date: 1/6/2025

Station	Offset	Initial Stresses	Final Stresses	Adopted
		(psf)	(psf)	Cv
		σ_o	σ_f	(ft2 / day)
2+04	8.5 RT	700	1940	0.135
	8.5 RT	1220	2400	0.133
	8.5 RT	1730	2820	0.128
	8.5 RT	2210	3260	0.123
2+04	CL	420	840	0.148
	CL	1230	1720	0.14
	CL	1860	2370	0.133
	CL	2320	2840	0.133
2+04	25 RT	1470	3000	0.133

2+93	8.5 LT	1160	1860	0.14
	8.5 LT	1660	2300	0.133
	8.5 LT	2180	2800	0.133
2+93	7.5RT	1400	2560	0.133
	7.5RT	1960	3060	0.133
2+93	25 RT	1210	1890	0.135
	25 RT	1520	2140	0.135
	25 RT	1730	2340	0.133

7+16	8 Lt	830	2100	0.133
	8 Lt	1240	2420	0.133
7+16	9.5 RT	790	2600	0.133
	9.5 RT	1450	3150	0.13
7+16	25 RT	1030	1780	0.145
	25 RT	1560	2310	0.133

5+82	7.5 LT	1160	1860	0.14
	7.5 LT	1660	2300	0.133
5+82	8.5 RT	740	2420	0.133
	8.5 RT	1240	2830	0.133
	8.5 RT	1780	3280	0.13
5+82	25LT	1030	1100	0.165
	25LT	1560	1640	0.14
	25LT	2120	2230	0.133

Effective Stresses (See attached lab results)

σ_f	B-001	B-003	AVG
800	0.08	0.205	0.143
830	0.085	0.21	0.148
900	0.09	0.22	0.155
930	0.095	0.225	0.160
1000	0.1	0.23	0.165
1300	0.115	0.19	0.153
2000	0.13	0.14	0.135
2300	0.13	0.135	0.133
3000	0.125	0.13	0.128
3300	0.125	0.12	0.123

Adopted Cv Values selected based on the average of the tested values for the respective stress.

Values were estimated or interpolated as needed.

Consolidation Test

Project Name: HAM-126-19.50

Prepared by: LR

Source: B-001-0-24 ST-4 (7.7'-7.8')

Checked by: ZM

Description: Very stiff, brown mottled with orangish brown and gray, CLAY,
some silt, little sand, trace gravel, damp.

Date: 11/18/2024

Test Specification: ASTM D 2435

Initial Void Ratio: 0.531

Initial Bulk Unit Weight (lb/ft³): 130

In-situ Vertical Effective Stress (psf): 924

Dry Unit Weight (lb/ft³): 110

Compression and Swelling Index

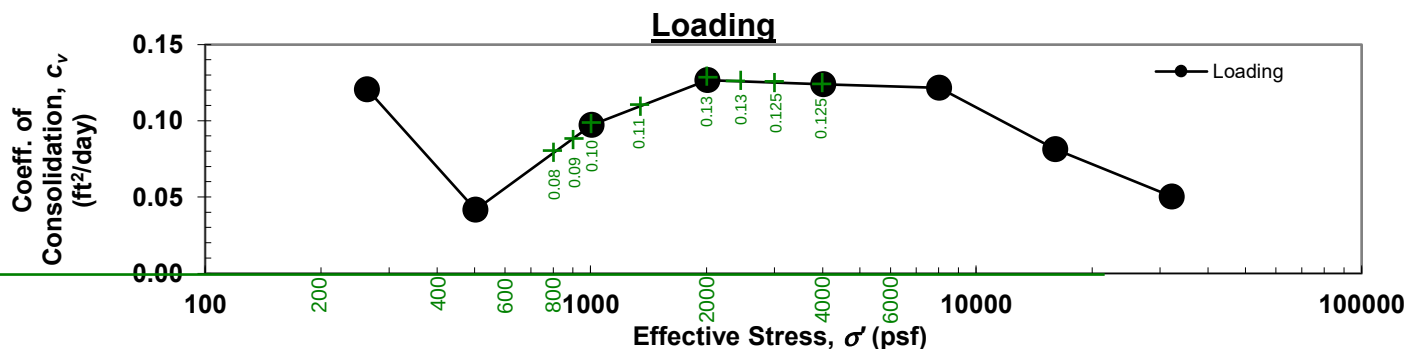
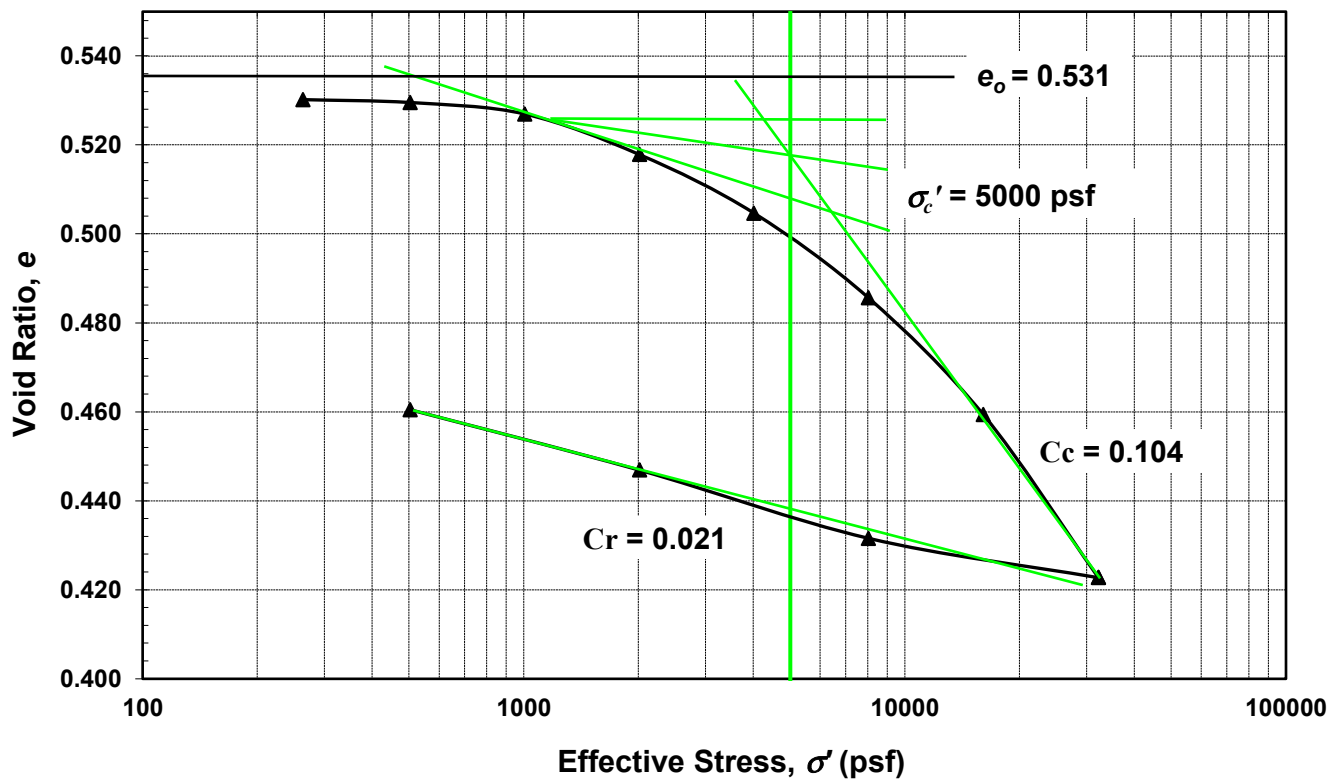
Compression Index (C_c): 0.104

Preconsolidation Pressure (σ_c')(psf): 5000

Recompression Index (C_r): 0.021

Over-Consolidation Ratio (OCR): 5.4

Consolidation Curve



Consolidation Test

Project Name: HAM-126-19.50

Prepared by: LR

Source: B-003-0-24 ST-1 (2.2'-2.3')

Checked by: ZM

Description: Hard, brown and gray, CLAY, some silt, little sand, trace gravel, damp.

Date: 11/18/2024

Test Specification: ASTM D 2435

Initial Void Ratio: 0.628

Initial Bulk Unit Weight (lb/ft³): 127

In-situ Vertical Effective Stress(psf): 264

Dry Unit Weight (lb/ft³): 104

Compression and Swelling Index

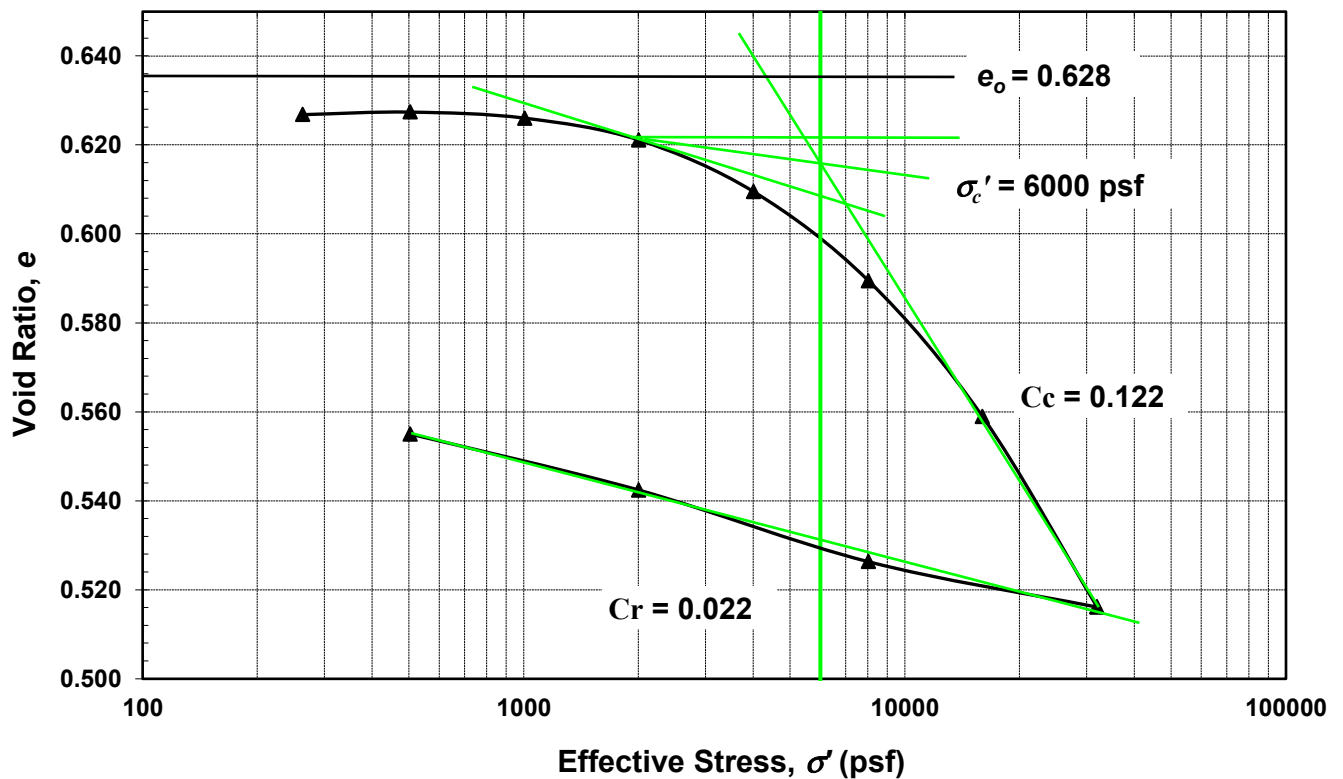
Compression Index (C_c): 0.122

Preconsolidation Pressure (σ'_c)(psf): 6000

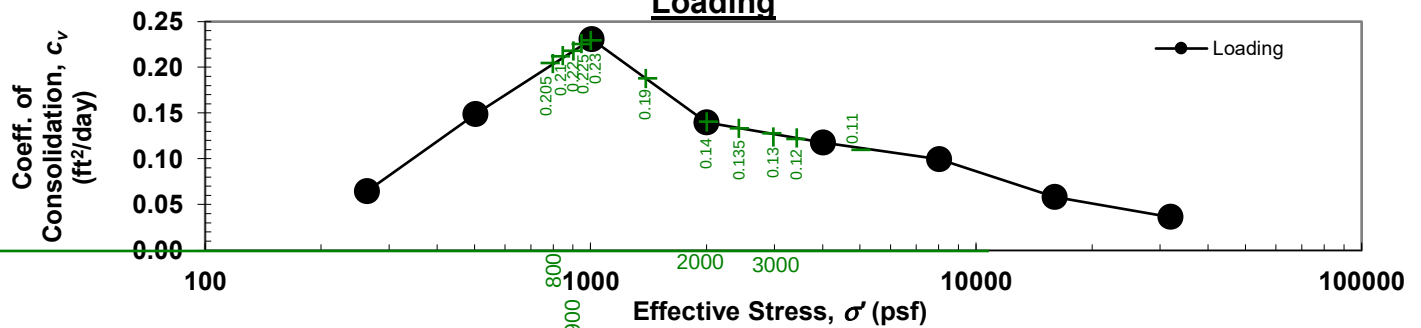
Recompression Index (C_r): 0.022

Over-Consolidation Ratio (OCR): 22.7

Consolidation Curve



Loading



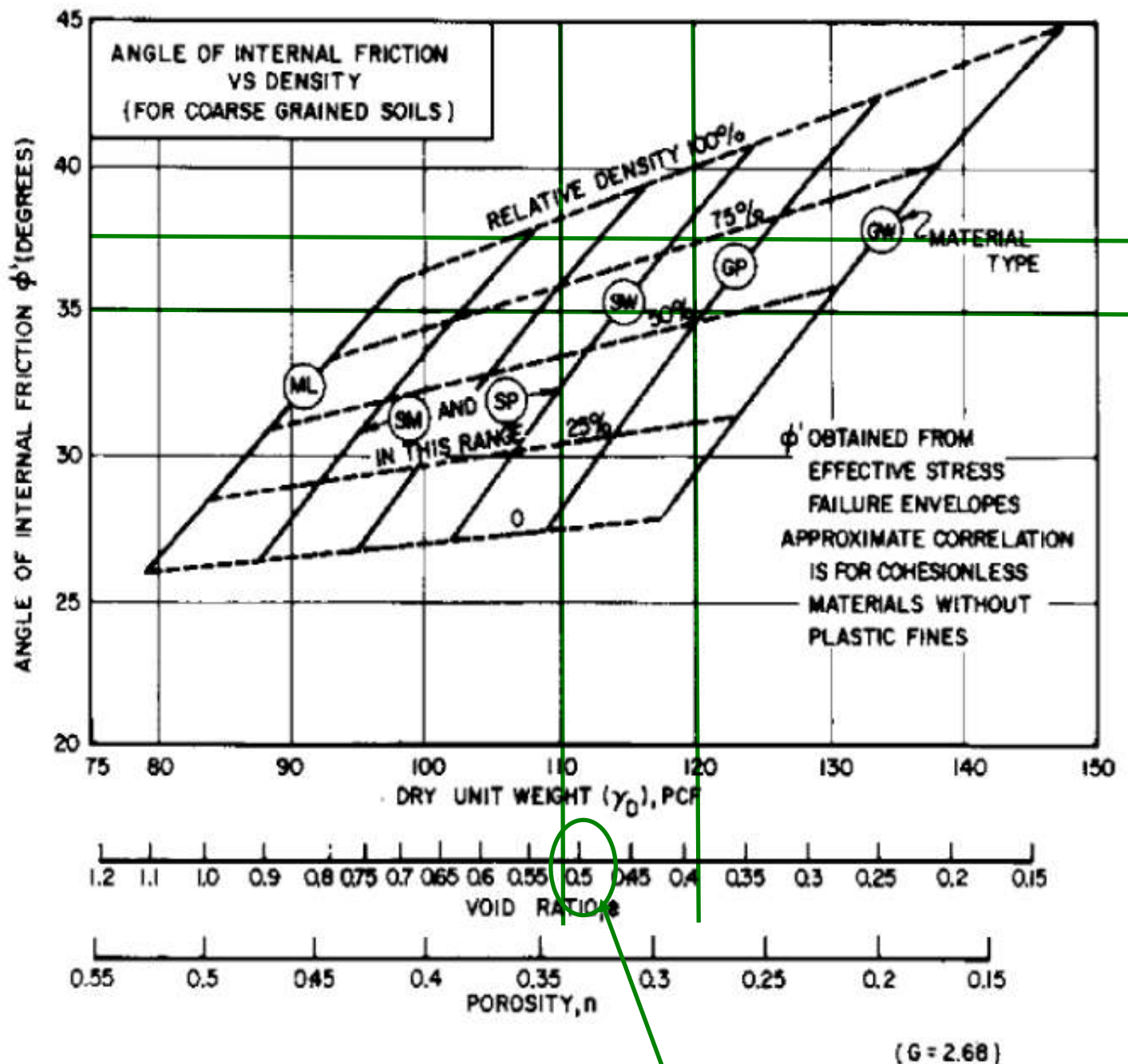


FIGURE 7
Correlations of Strength Characteristics for Granular Soils

NavFac Design Manual 7.1

Use $e = 0.5$ for Dense Granular Native material and High Strength Granular Material (MSE Wall)

Table C10.4.6.3-1—Elastic Constants of Various Soils
(modified after U.S. Department of the Navy, 1982;
Bowles, 1988)

ODOT Classification

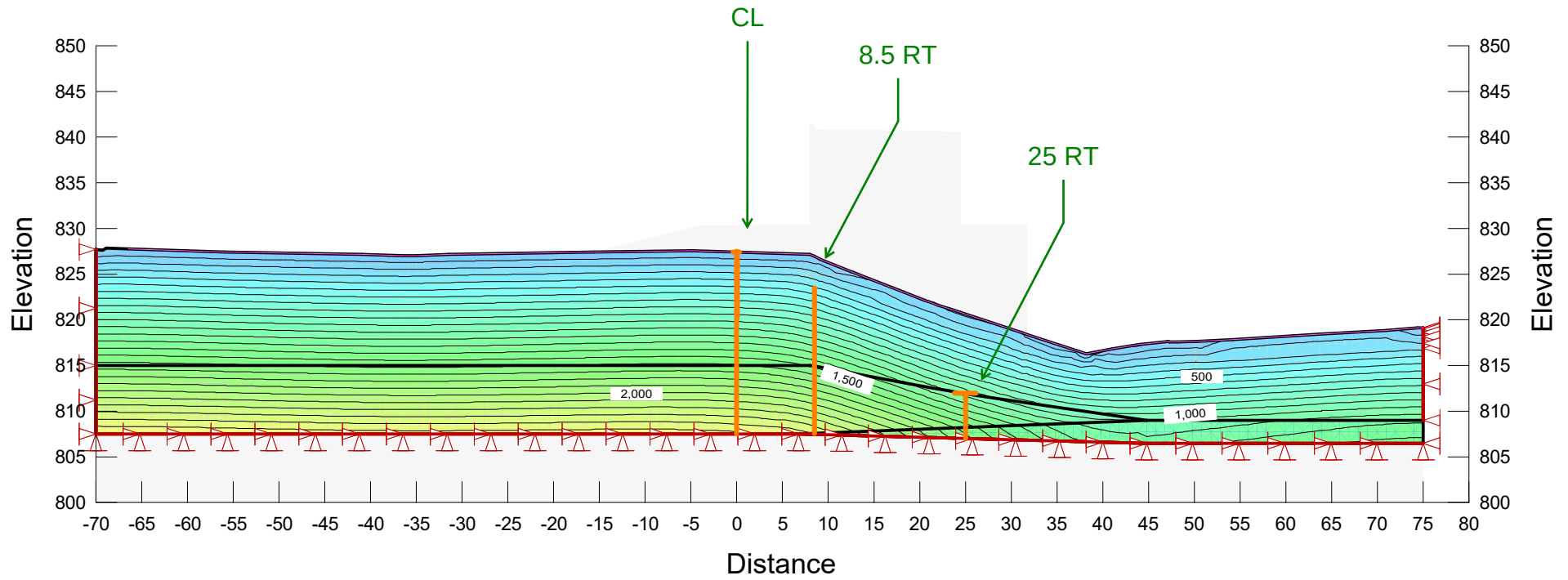
Description	Qu (tsf)	c (psf)	BPF	Soil Type	Typical Range of Young's Modulus Values, E_s (ksi)	Poisson's Ratio, ν (dim)	Typical Range of Young's Modulus, E_s (psf)
V. Soft to Soft	<0.25 - 0.5	250—500	<2 - 4	Clay: Soft sensitive	0.347—2.08	0.4—0.5 (undrained)	49,968—299,520
Medium Stiff to Stiff	0.5 - 2.0	500—2000	5 - 15	Medium stiff to stiff	2.08—6.94		299,520—999,360
Very Stiff	2.0 - 4.0	2000—4000	15 - 30	Very stiff	6.94—13.89		999,360—2,000,160
				Loess	2.08—8.33	0.1—0.3	299,520—1,199,520
				Silt	0.278—2.78	0.3—0.35	40,032—400,320
Very Loose to Loose	NA	<4 - 10		Fine Sand: Loose	1.11—1.67	0.25	159,840—240,480
Medium Dense	NA	11 - 30		Medium dense	1.67—2.78		240,480—400,320
Dense	NA	>31		Dense	2.78—4.17		400,320—600,480
Very Loose to Loose	NA	<4 - 10		Sand: Loose	1.39—4.17	0.20—0.36	200,160—600,480
Medium Dense	NA	11 - 30		Medium dense	4.17—6.94		600,480—999,360
Dense	NA	>31		Dense	6.94—11.11	0.30—0.40	999,360—1,599,840
Very Loose to Loose	NA	<4 - 10		Gravel: Loose	4.17—11.11	0.20—0.35	600,480—1,599,840
Medium Dense	NA	11 - 30		Medium dense	11.11—13.89		1,599,840—2,000,160
Dense	NA	>31		Dense	13.89—27.78	0.30—0.40	2,000,160—4,000,320

Soil Parameters for Settlement Analysis

Material	Cohesion (psf)	Phi (deg)	E_s (psf)	ν (dim)	E_0 , Initial Void Ratio (From Testing)
Item 203 Embankment	2000	0	999,360	0.45	0.30
Layer 1—Medium Stiff Cohesive	750	0	416,160	0.45	0.888
Layer 2 - Very Stiff Cohesive	2400	0	1,199,520	0.45	0.580
Layer 3 - Hard Cohesive	4000	0	2,000,160	0.45	0.580
Layer 4 - Dense Granular	0	37	2,000,160	0.3	0.5
MSE Retained	0	30	2,000,160	0.3	0.5
MSE Reinforced	0	34	2,000,160	0.3	0.5
Modulus Values interpolated based on determined strength values and ranges provided in table.					

Name: 2+04_In Situ
 Kind: SIGMA/W
 Analysis Type: In Situ
 Description: Stress Analysis

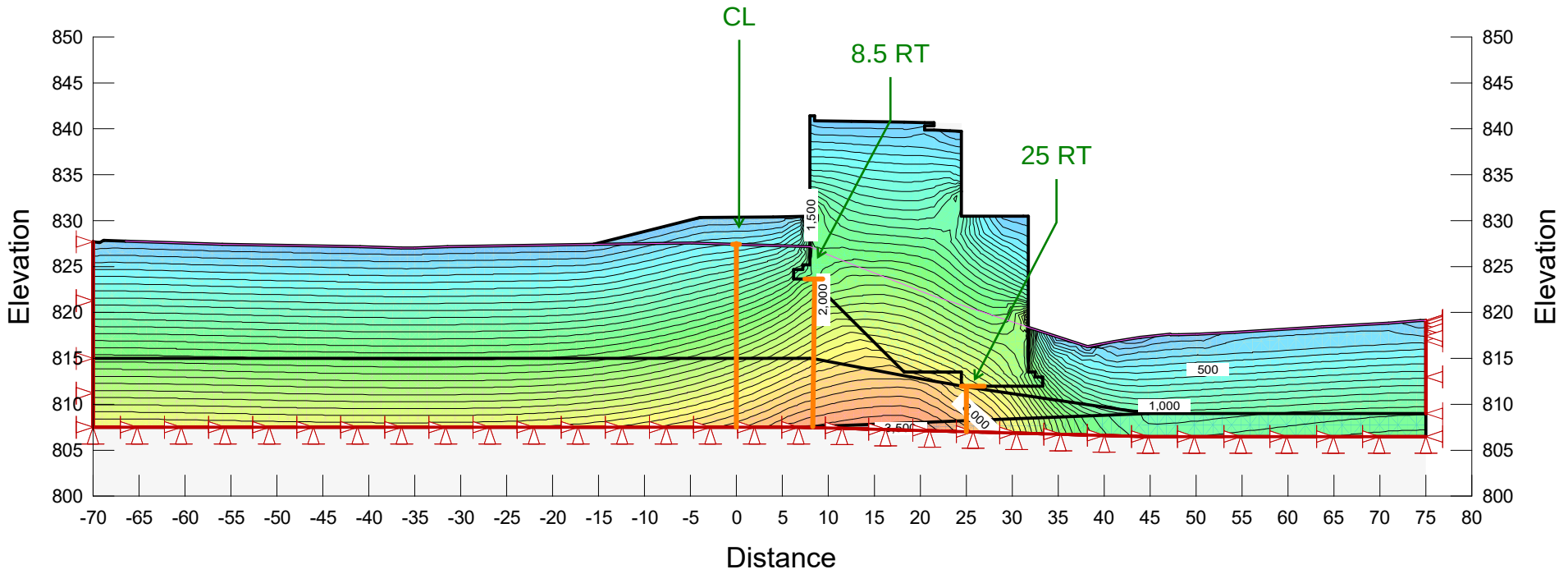
Settlement Analysis Locations



Color	Name	Stress Material Model	Initial Void Ratio	Unit Weight (pcf)	Response Type	Effective Elastic Modulus (psf)	Effective Poisson's Ratio	Hydraulic Material Model
	Layer 2- Very Stiff Cohesive (LT)	Isotropic Elastic	0.58	130	Drained	1,199,520	0.45	(none)
	Layer 3- Hard Cohesive (LT)	Isotropic Elastic	0.58	130	Drained	2,000,160	0.45	(none)
	Layer 4- Dense Granular	Isotropic Elastic	0.5	120	Drained	2,000,160	0.3	(none)

Name: 2+04_Load/Deformation
Kind: SIGMA/W
Analysis Type: Load/Deformation
Description: Stress Analysis

Settlement Analysis Locations



Color	Name	Stress Material Model	Initial Void Ratio	Unit Weight (pcf)	Response Type	Effective Elastic Modulus (psf)	Effective Poisson's Ratio	Hydraulic Material Model
	High Strength	Isotropic Elastic	0.5	120	Drained	2,000,160	0.3	(none)
	Item 203 Embankment Fill (LT)	Isotropic Elastic	0.3	125	Drained	999,360	0.45	(none)
	Layer 2- Very Stiff Cohesive (LT)	Isotropic Elastic	0.58	130	Drained	1,199,520	0.45	(none)
	Layer 3- Hard Cohesive (LT)	Isotropic Elastic	0.58	130	Drained	2,000,160	0.45	(none)
	Layer 4- Dense Granular	Isotropic Elastic	0.5	120	Drained	2,000,160	0.3	(none)

Project: HAM-126-19.50
Subject: Sta. 2+04, CL
Task: Settlement

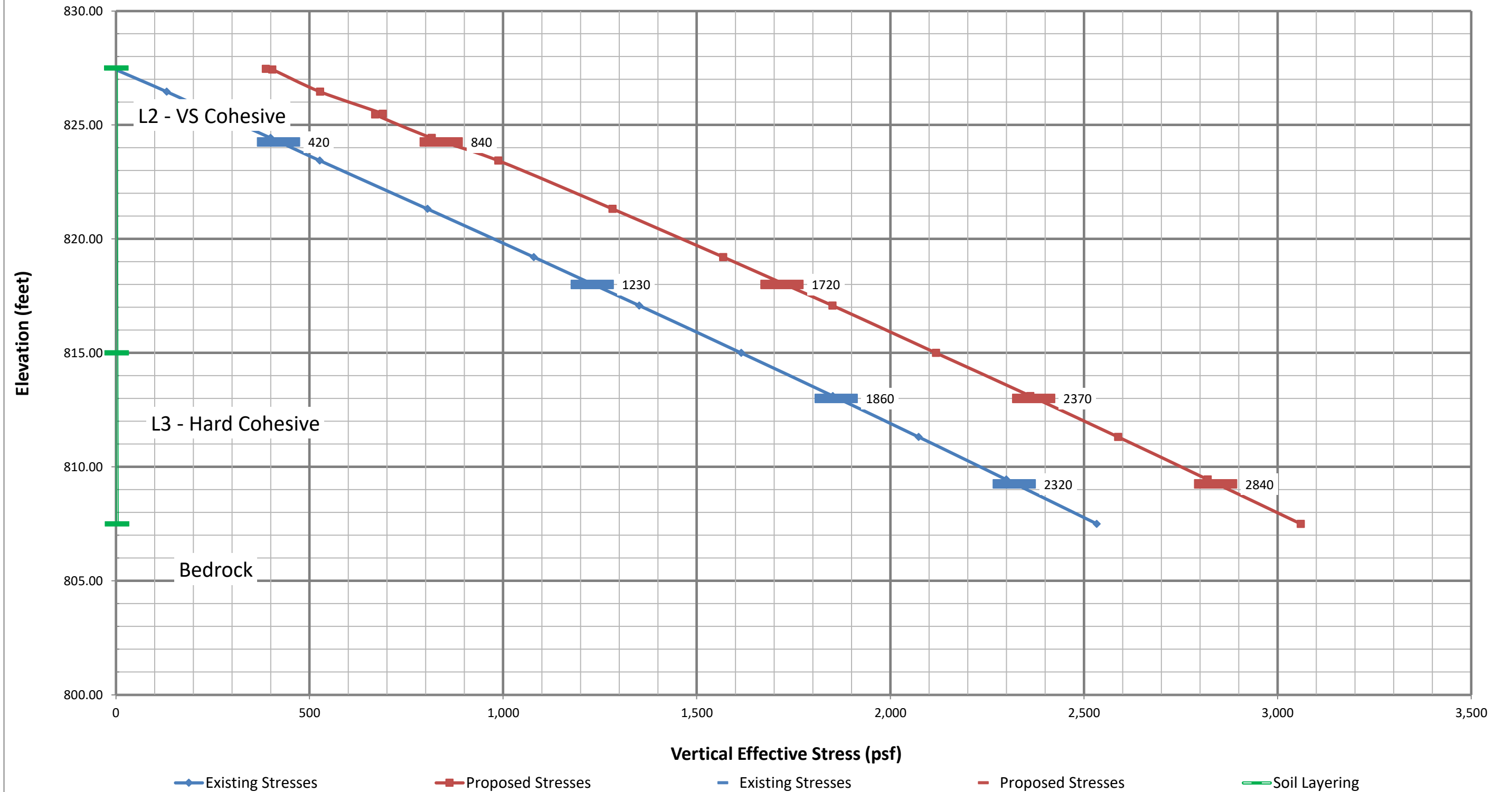
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Checked: <u>MM</u>	Date: <u>1/3/2025</u>
Rechecked: _____	Date: _____

4 OK

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HAM-126-19.50
Distribution of Vertical Effective Stress
Sta. 2+04 / CL



HDR Computation

Project: HAM-126-19.50

Subject: Sta. 2+04, CL

Task: Settlement

Normally Consolidated Soil

$$S = \sum \left[\frac{C_c}{1 + e_0} \cdot H \cdot \log \left(\frac{\sigma_f'}{\sigma_0'} \right) \right]$$

Overlyconsolidated Soil ($\sigma'_0 < \sigma'_p < \sigma_f$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma'_p}{\sigma_0} \right) + \frac{C_c}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma'_f}{\sigma_p} \right) \right]$$

Cohesionless Soil Using Elastic Theory

$$S_e = \sum_{i=1}^n \Delta H_i$$

$$\Delta H_i = H_c \frac{1}{C'} \log \left(\frac{\sigma'_o + \Delta \sigma_v}{\sigma'_o} \right)$$

Overlyconsolidated Soil ($\sigma'_F < \sigma'_P$)

$$S = \sum \left[\frac{C_r}{1 + e_0} \cdot H \cdot \log \left(\frac{\sigma'_f}{\sigma'_0} \right) \right]$$

Soil Type	Top	Bottom	Thickness	Layers
L2 - VS Cohesive	827.5	815	12.5	2
L3 - Hard Cohesive	815	807.5	7.5	2
Bedrock	807.5	0	807.5	0

S_e = total elastic (immediate) settlement
 n = number of soil layers within zone of stress influence of the footing
 H_i = Elastic (Immediate) settlement of Layer i (ft)
 H_c = Initial height of layer i (ft)
 C' = bearing capacity index from Figure 10.6.2.4.2-1
 (AASHTO LRFD Bridge Design Manual - 2012)
 $1 = N(C_N)$
 $N1$ = SPT Blow count corrected for overburden pressure, σ'_v
 $C_N = [0.77 \log_{10} (40/\sigma'_v)]$, where $C_N < 2.0$

[illegible]

	0.050	ft
Total Settlement	0.59	in

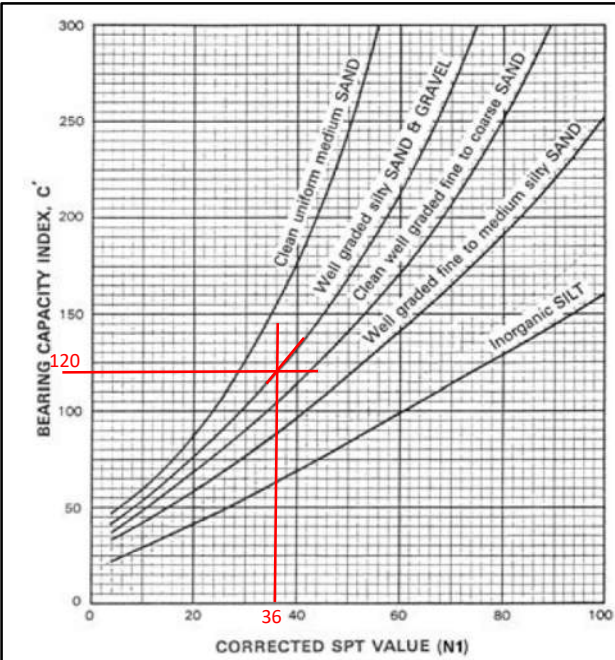


Figure 10.6.2.4.2-1—Bearing Capacity Index versus Corrected SPT (modified from Cheney and Chassie, 2000, after Hough, 1959)

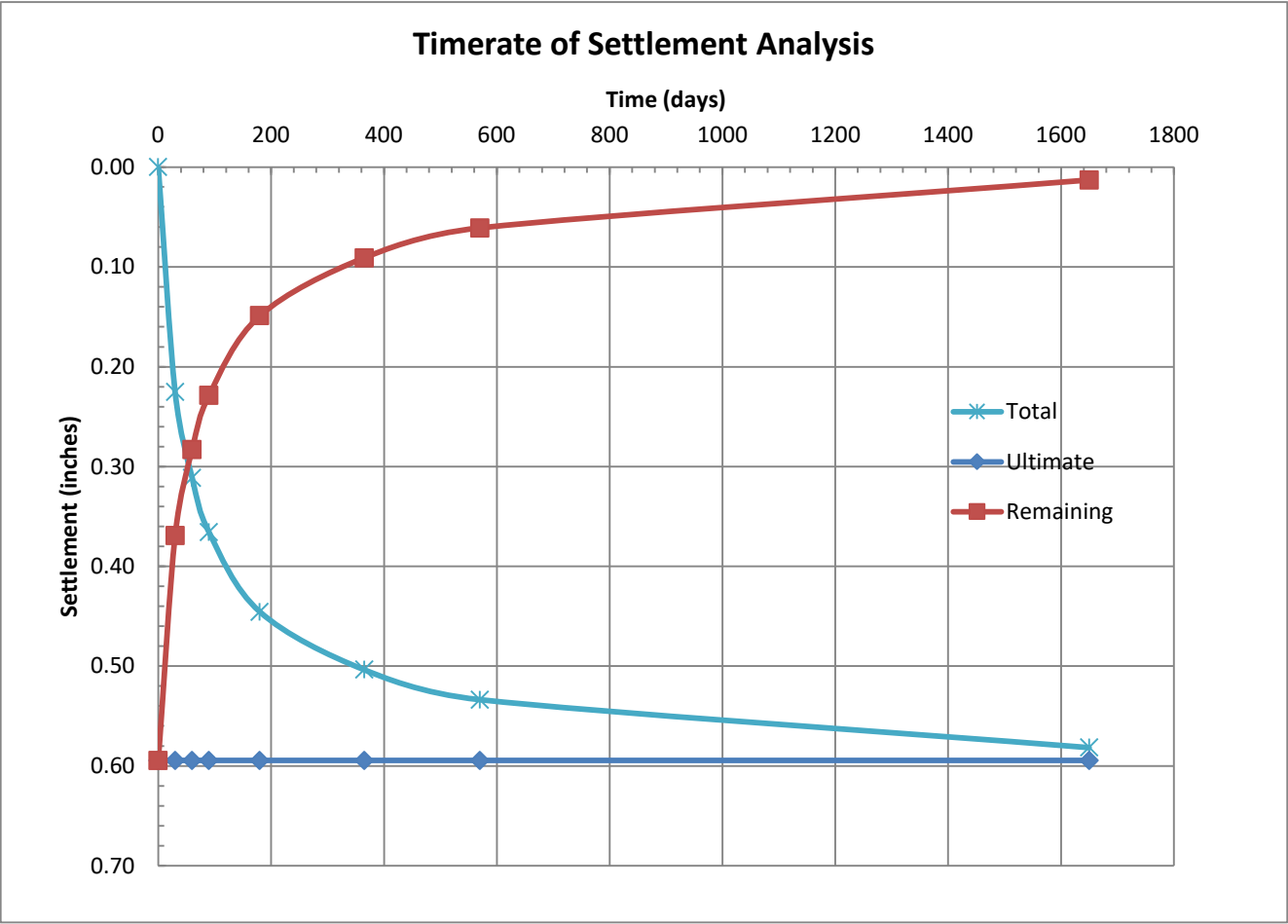
	Approximate Consolidation	
Consolidation	50%	90%
Time (days)	60	570
Time (Months)	2.0	19

TIME RATE OF SETTLEMENT

HDR Computation

Project:	HAM-126-19.50	Computed:	DCM	Date:	12/29/2024
Subject:	Sta. 2+04, CL	Checked:	MM	Date:	1/3/2025
Task:	Settlement	Sheet:	2	of	2

Time	Total	Total	Ultimate	Remaining	%
days	Settlement (ft)	Settlement (inches)	Settlement (inches)	Settlement (inches)	Consolidation
0	0.00	0.00	0.59	0.59	0
30	0.02	0.23	0.59	0.37	38
60	0.03	0.31	0.59	0.28	52
90	0.03	0.37	0.59	0.23	62
180	0.04	0.45	0.59	0.15	75
365	0.04	0.50	0.59	0.09	85
570	0.04	0.53	0.59	0.06	90
1650	0.05	0.58	0.59	0.01	98

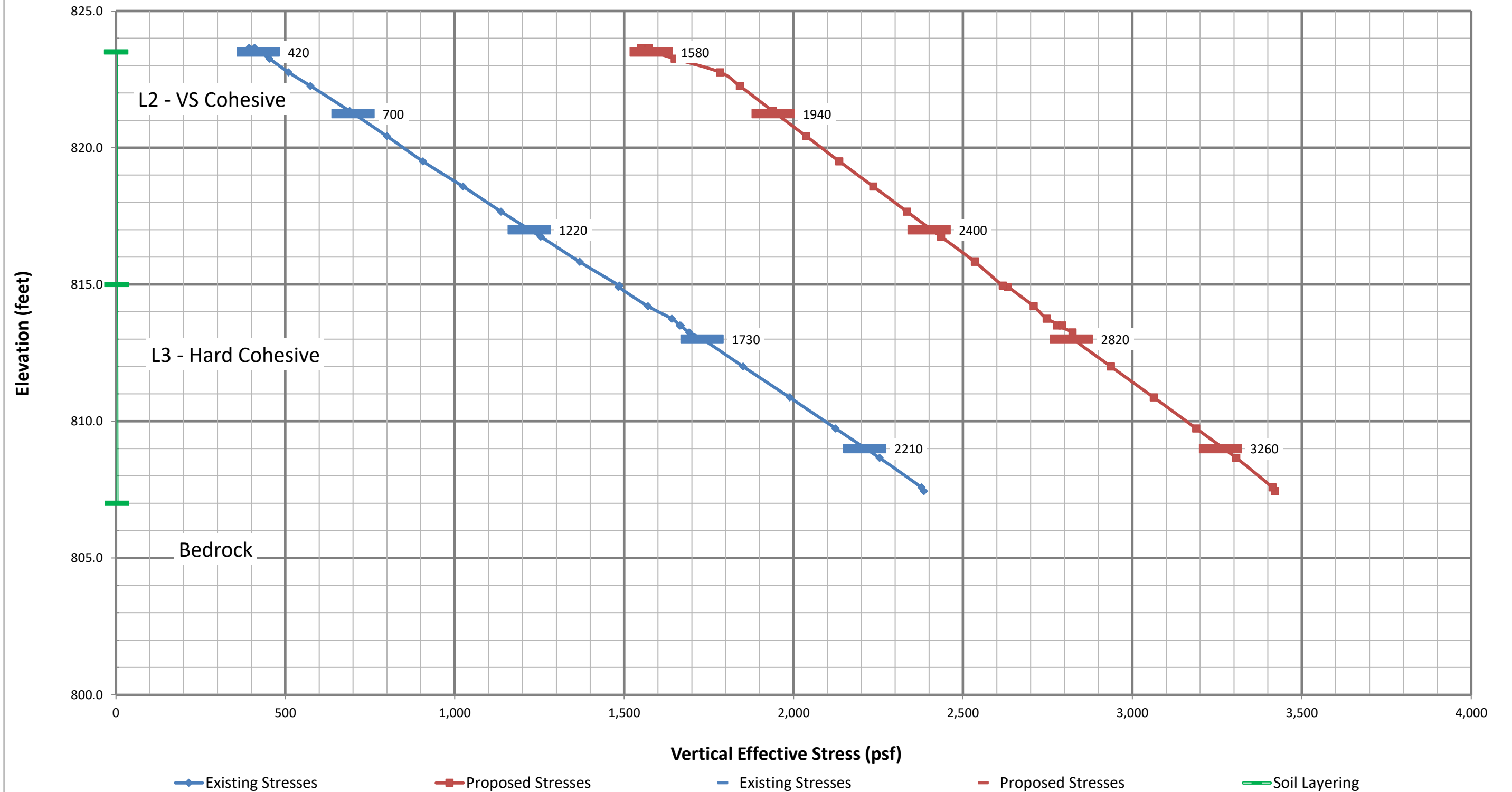


Project: HAM-126-19.50
Subject: Sta. 2+04, 8.5 RT
Task: Settlement

Soil Type	Top	Bottom	Thickness	Layers
L2 - VS Cohesive	823.5	815	8.5	2
L3 - Hard Cohesive	815	807	8	2
Bedrock	807		807	

[illegible]

HAM-126-19.50
Distribution of Vertical Effective Stress
Sta 2+04 / 8.5 RT



Project: HAM-126-19.50

Subject: Sta. 2+04, 8.5 RT

Task: Settlement

The graph plots the Bearing Capacity Index (C') on the vertical axis (0 to 300) against the Corrected SPT Value (N_1) on the horizontal axis (0 to 100). Five curves represent different soil types:

- Clean uniform medium SAND
- Well graded silty SAND & GRAVEL
- Clean well graded fine to coarse SAND
- Well graded fine to medium silty SAND
- Inorganic SILT

A red cross indicates a specific data point where $C' = 120$ and $N_1 = 36$.

	Approximate Consolidation	
Consolidation	50%	90%
Time (days)	60	480
Time (Months)	2.0	16

$$S = \sum \left[\frac{C_c}{1 + e_0} \cdot H \cdot \log \left(\frac{\sigma_f'}{\sigma_0'} \right) \right]$$

$$S = \sum \left[\frac{C_r}{1 + e_0} \cdot H \cdot \log \left(\frac{\sigma'_f}{\sigma'_0} \right) \right]$$

Soil Type	Top	Bottom	Thickness	Layers
L2 - VS Cohesive	823.5	815	8.5	2
L3 - Hard Cohesive	815	807	8	2
Bedrock	807	0	807	0

$$S = \sum \left[\frac{C_r}{1 + e_0} \cdot H \cdot \log \left(\frac{\sigma'_p}{\sigma'_0} \right) + \frac{C_c}{1 + e_0} \cdot H \cdot \log \left(\frac{\sigma'_f}{\sigma'_p} \right) \right]$$

$$S_e = \sum_{i=1}^n \Delta H_i$$

$$\Delta H_i = H_c \frac{1}{C'} \log \left(\frac{\sigma'_o + \Delta \sigma_v}{\sigma'_o} \right)$$

S_e = total elastic (immediate) settlement
 n = number of soil layers within zone of stress influence of the footing
 ΔH_i = Elastic (Immediate) settlement of Layer i (ft)
 H_c = Initial height of layer i (ft)
 C' = bearing capacity index from Figure 10.6.2.4.2-1
 (AASHTO LRFD Bridge Design Manual - 2012)
 $1 = N(C_N)$
 $N1$ = SPT Blow count corrected for overburden pressure, σ'_{v1}
 $C_N = [0.77 \log_{10} (40/\sigma'_{v1})]$, where $C_N < 2.0$

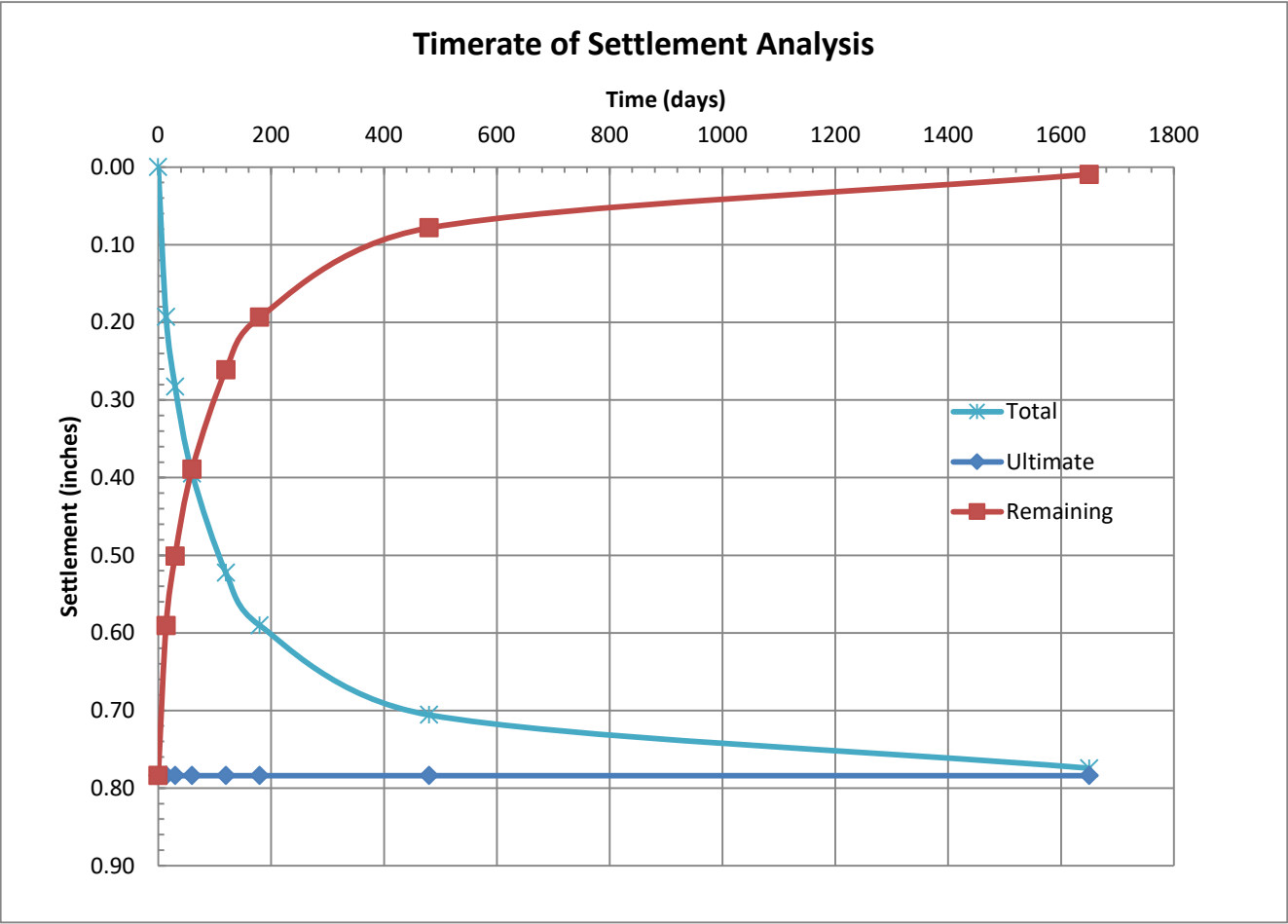
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TIME RATE OF SETTLEMENT

HDR Computation

Project:	HAM-126-19.50	Computed:	DCM	Date:	12/29/2024
Subject:	Sta. 2+04, 8.5 RT	Checked:	MM	Date:	1/3/2025
Task:	Settlement	Sheet:	2	of	2

Time	Total	Total	Ultimate	Remaining	%
days	Settlement (ft)	Settlement (inches)	Settlement (inches)	Settlement (inches)	Consolidation
0	0.00	0.00	0.78	0.78	0
14	0.02	0.19	0.78	0.59	25
30	0.02	0.28	0.78	0.50	36
60	0.03	0.39	0.78	0.39	50
120	0.04	0.52	0.78	0.26	67
180	0.05	0.59	0.78	0.19	75
480	0.06	0.71	0.78	0.08	90
1650	0.06	0.77	0.78	0.01	99



Project: HAM-126-19.50

Subject: Sta. 2+04, 25 RT

Task: Settlement

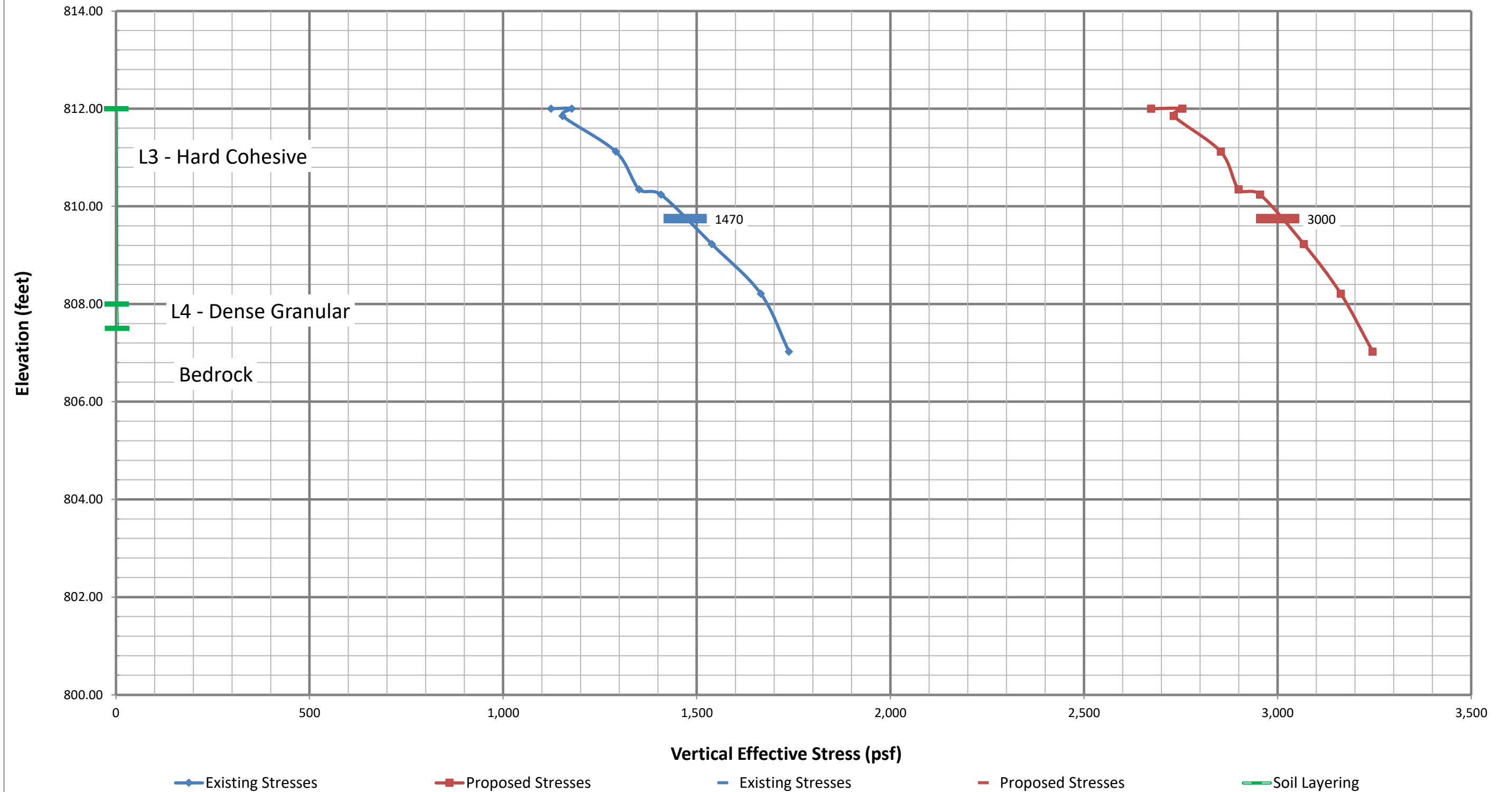
Soil Type	Top	Bottom	Thickness	Layers
L3 - Hard Cohesive	812	808	4	1
L4 - Dense Granular	808	807.5	0.5	0
Bedrock	807.5		807.5	

1

OK

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HAM-126-19.50
Distribution of Vertical Effective Stress
Sta 2+04 / 25 RT



HDR Computation

Project: HAM-126-19.50

Subject: Sta. 2+04, 25 RT

Task: Settlement

Normally Consolidated Soil

$$S = \sum \left[\frac{C_c}{1 + e_0} \cdot H \cdot \log \left(\frac{\sigma_f'}{\sigma_0'} \right) \right]$$

Overlyconsolidated Soil ($\sigma'_0 < \sigma'_p < \sigma'_f$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma'_p}{\sigma'_0} \right) + \frac{C_c}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma'_f}{\sigma'_p} \right) \right]$$

Cohesionless Soil Using Elastic Theory

$$S_e = \sum_{i=1}^n \Delta H_i$$

$$\Delta H_i = H_c \frac{1}{C'} \log \left(\frac{\sigma'_o + \Delta \sigma_v}{\sigma'_o} \right)$$

Overlyconsolidated Soil ($\sigma'_F < \sigma'_p$)

$$S = \sum \left[\frac{C_r}{1 + e_0} \cdot H \cdot \log \left(\frac{\sigma'_f}{\sigma'_0} \right) \right]$$

Soil Type	Top	Bottom	Thickness	Layers
L3 - Hard Cohesive	812	808	4	1
L4 - Dense Granular	808	807.5	0.5	0
Bedrock	807.5	0	807.5	0

S_e = total elastic (immediate) settlement
 n = number of soil layers within zone of stress influence of the footing
 H_i = Elastic (Immediate) settlement of Layer i (ft)
 H_c = Initial height of layer i (ft)
 C' = bearing capacity index from Figure 10.6.2.4.2-1
 (AASHTO LRFD Bridge Design Manual - 2012)
 $1 = N(C_N)$
 $N1$ = SPT Blow count corrected for overburden pressure, σ'_v
 $C_N = [0.77 \log_{10} (40/\sigma'_v)]$, where $C_N < 2.0$

<u>Existing Ground Surface</u>	812	ft.
<u>Top of Drainage Layer</u>	812	ft.
<u>Bottom of Drainage Layer</u>	812	ft.

[illegible]

	0.019	ft
Total Settlement	0.23	in

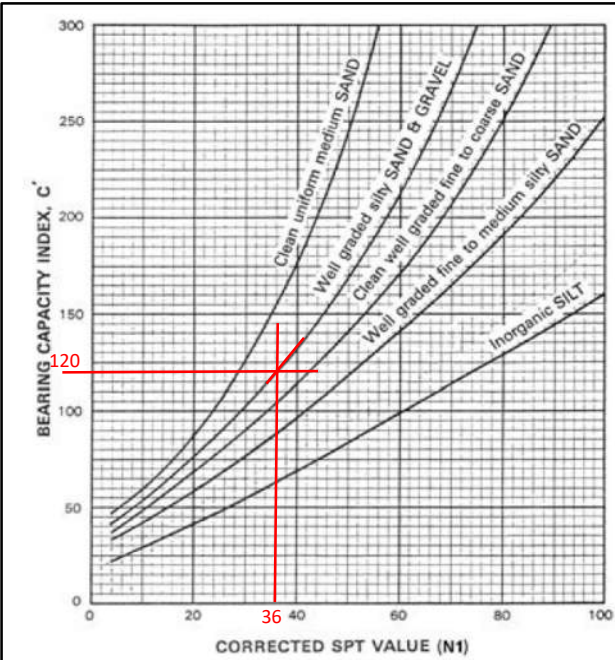


Figure 10.6.2.4.2-1—Bearing Capacity Index versus Corrected SPT (modified from Cheney and Chassie, 2000, after Hough, 1959)

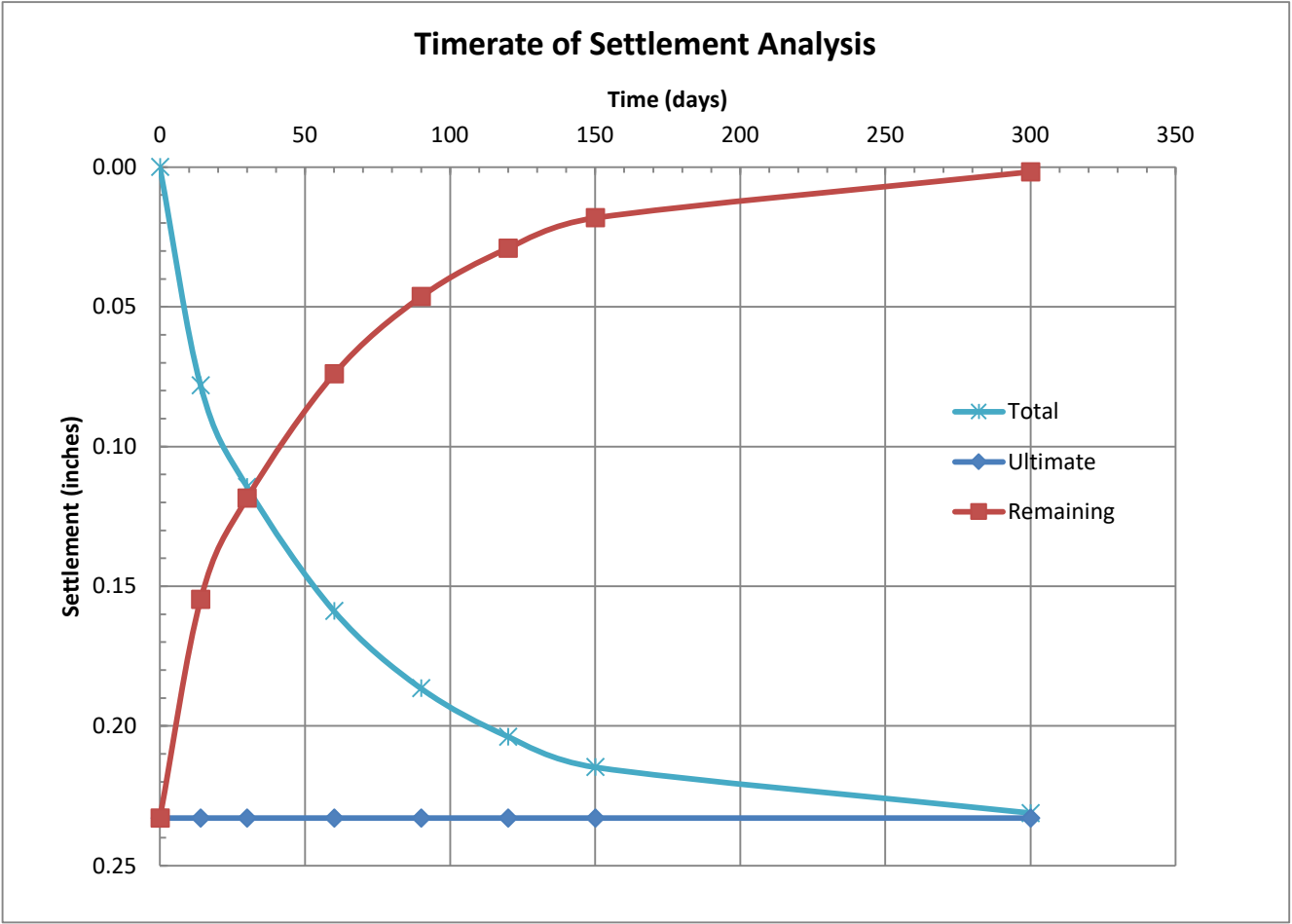
	Approximate Consolidation	
Consolidation	50%	92%
Time (days)	30	150
Time (Months)	1.0	5

TIME RATE OF SETTLEMENT

HDR Computation

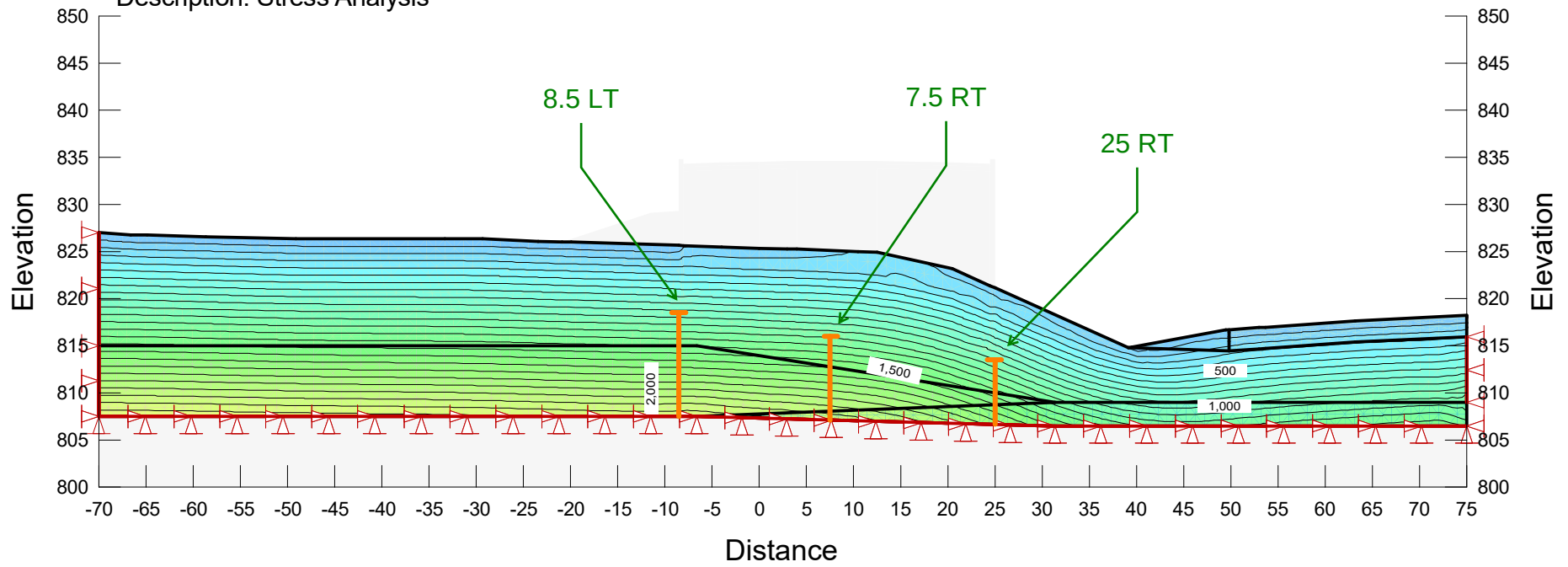
Project:	HAM-126-19.50	Computed:	DCM	Date:	12/29/2024
Subject:	Sta. 2+04, 25 RT	Checked:	MM	Date:	1/3/2025
Task:	Settlement	Sheet:	2	of	2

Time	Total	Total	Ultimate	Remaining	%
days	Settlement (ft)	Settlement (inches)	Settlement (inches)	Settlement (inches)	Consolidation
0	0.00	0.00	0.23	0.23	0
14	0.01	0.08	0.23	0.15	34
30	0.01	0.11	0.23	0.12	49
60	0.01	0.16	0.23	0.07	68
90	0.02	0.19	0.23	0.05	80
120	0.02	0.20	0.23	0.03	88
150	0.02	0.21	0.23	0.02	92
300	0.02	0.23	0.23	0.00	99



Name: 2+93_In Situ
Kind: SIGMA/W
Analysis Type: In Situ
Description: Stress Analysis

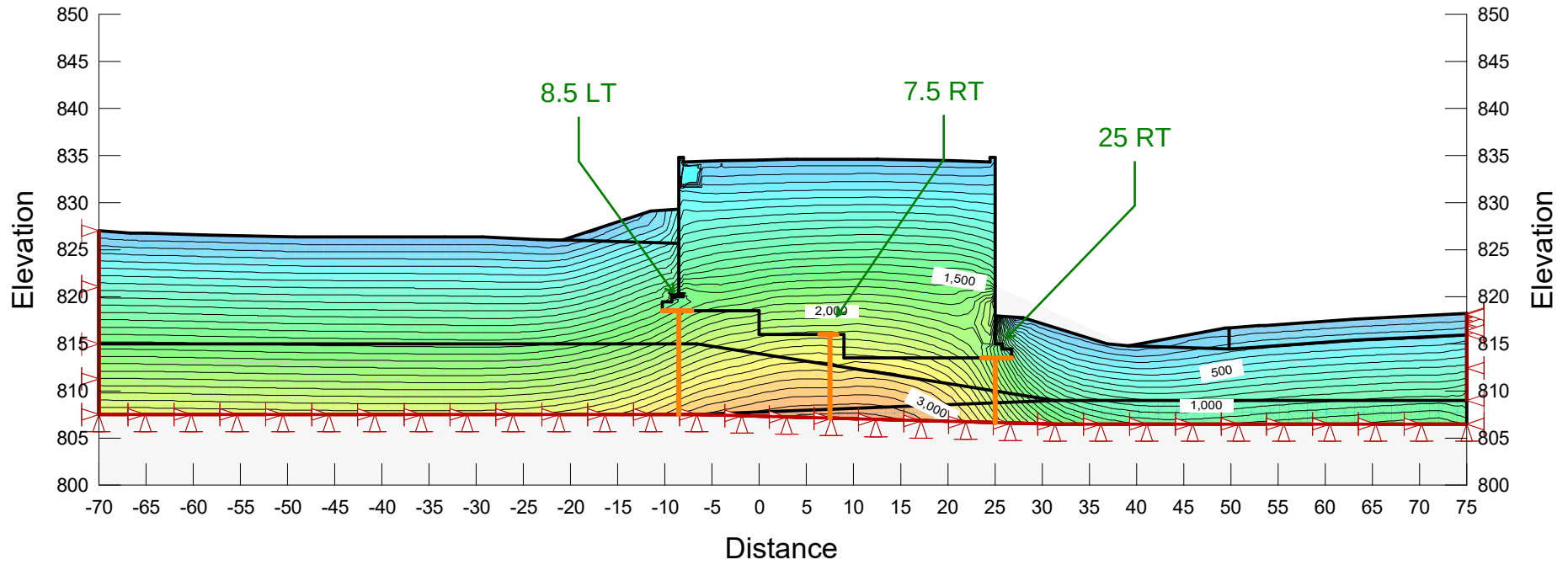
Settlement Analysis Locations



Color	Name	Stress Material Model	Initial Void Ratio	Unit Weight (pcf)	Response Type	Effective Elastic Modulus (psf)	Effective Poisson's Ratio	Hydraulic Material Model
	Item 203 Embankment Fill (LT)	Isotropic Elastic	0.3	125	Drained	999,360	0.45	(none)
	Layer 1- Medium Stiff Cohesive (LT)	Isotropic Elastic	0.888	110	Drained	416,160	0.45	(none)
	Layer 2- Very Stiff Cohesive (LT)	Isotropic Elastic	0.58	130	Drained	1,199,520	0.45	(none)
	Layer 3- Hard Cohesive (LT)	Isotropic Elastic	0.58	130	Drained	2,000,160	0.45	(none)
	Layer 4- Dense Granular	Isotropic Elastic	0.5	120	Drained	2,000,160	0.3	(none)

Name: 2+93_Load/Deformation
Kind: SIGMA/W
Analysis Type: Load/Deformation
Description: Stress Analysis

Settlement Analysis Locations

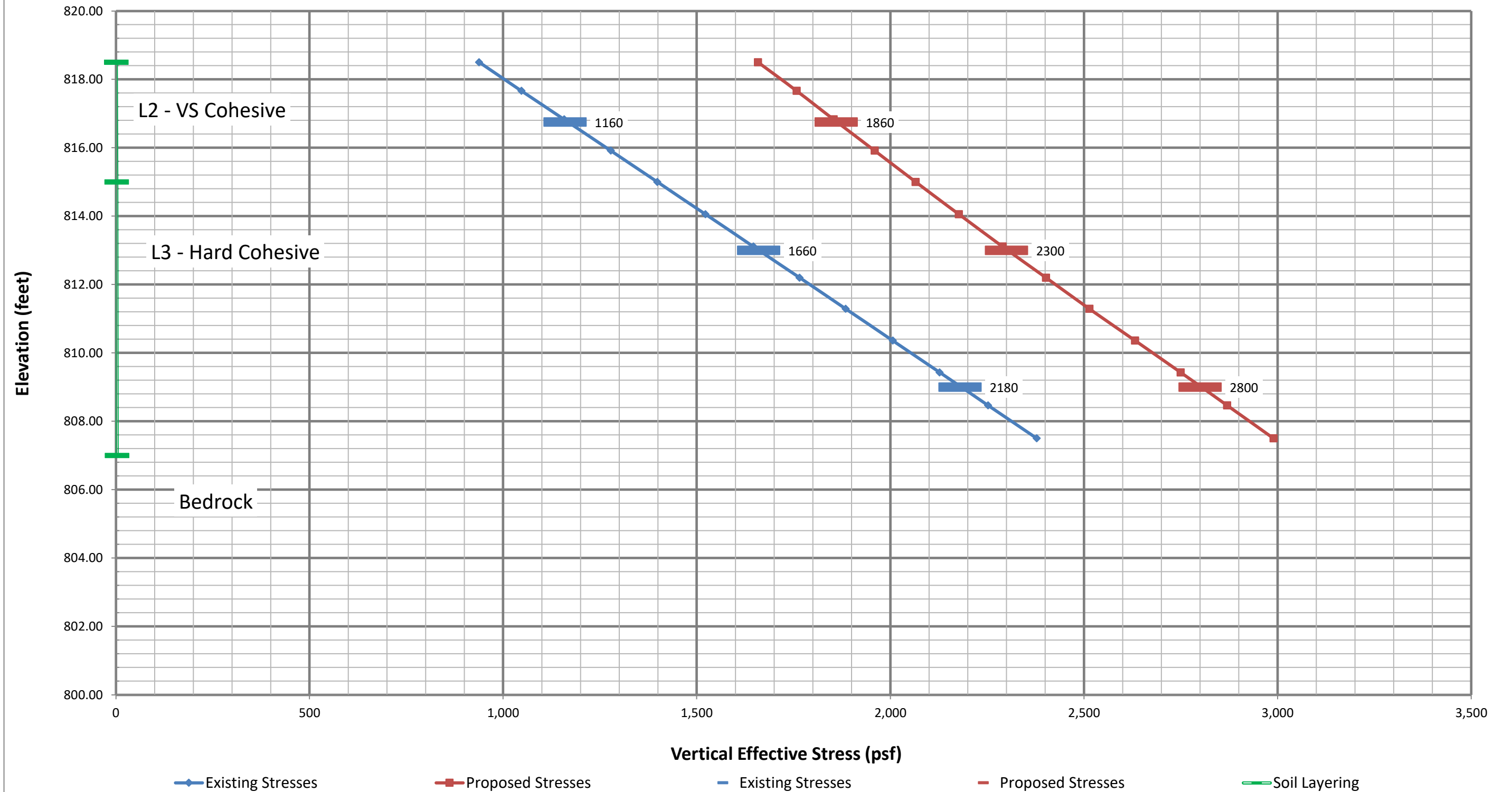


Color	Name	Stress Material Model	Initial Void Ratio	Unit Weight (pcf)	Response Type	Effective Elastic Modulus (psf)	Effective Poisson's Ratio	Hydraulic Material Model
■	High Strength	Isotropic Elastic	0.5	120	Drained	2,000,160	0.3	(none)
■	Item 203 Embankment Fill (LT)	Isotropic Elastic	0.3	125	Drained	999,360	0.45	(none)
■	Layer 1- Medium Stiff Cohesive (LT)	Isotropic Elastic	0.888	110	Drained	416,160	0.45	(none)
■	Layer 2- Very Stiff Cohesive (LT)	Isotropic Elastic	0.58	130	Drained	1,199,520	0.45	(none)
■	Layer 3- Hard Cohesive (LT)	Isotropic Elastic	0.58	130	Drained	2,000,160	0.45	(none)
■	Layer 4- Dense Granular	Isotropic Elastic	0.5	120	Drained	2,000,160	0.3	(none)

HAM-126-19.50 - Pedestrian Bridge

Distribution of Vertical Effective Stress

Sta. 2+93 , 8.5 RT



Project: HAM-126-19.50

Subject: Sta. 2+93, 8.5 LT

Task: Settlement

Reference: Hough, "Compressibility of Soils as a Basis for Soil Bearing Capacity," ASCE 1955

	Approximate Consolidation	
Consolidation	50%	91%
Time (days)	14	270
Time (Months)	0.5	9

$$S = \sum \left[\frac{C_c}{1 + e_0} \cdot H \cdot \log \left(\frac{\sigma_f'}{\sigma_0'} \right) \right]$$
$$S = \sum \left[\frac{C_r}{1 + e_0} \cdot H \cdot \log \left(\frac{\sigma'_f}{\sigma'_0} \right) \right]$$
$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma'_p}{\sigma_0} \right) + \frac{C_c}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma'_f}{\sigma_p} \right) \right]$$

Soil Type		Top	Bottom	Thickness	Layers
L2 - VS Cohesive		818.5	815	3.5	1
L3 - Hard Cohesive		815	807	8	2
Bedrock		807	0	807	0

$$S_e = \sum_{i=1}^n \Delta H_i$$

$$\Delta H_i = H_c \frac{1}{C'} \log \left(\frac{\sigma'_o + \Delta \sigma_v}{\sigma'_o} \right)$$

S_e = total elastic (immediate) settlement
 n = number of soil layers within zone of stress influence of the footing
 ΔH_i = Elastic (Immediate) settlement of Layer i (ft)
 H_c = Initial height of layer i (ft)
 C' = bearing capacity index from Figure 10.6.2.4.2-1
 (AASHTO LRFD Bridge Design Manual - 2012)
 $1 = \frac{N}{N_1} \left(\frac{C_N}{C_{N1}} \right)^{0.5}$
 N_1 = SPT Blow count corrected for overburden pressure, σ'_{v1}
 $C_N = [0.77 \log_{10} (40/\sigma'_{v1})]$, where $C_N < 2.0$

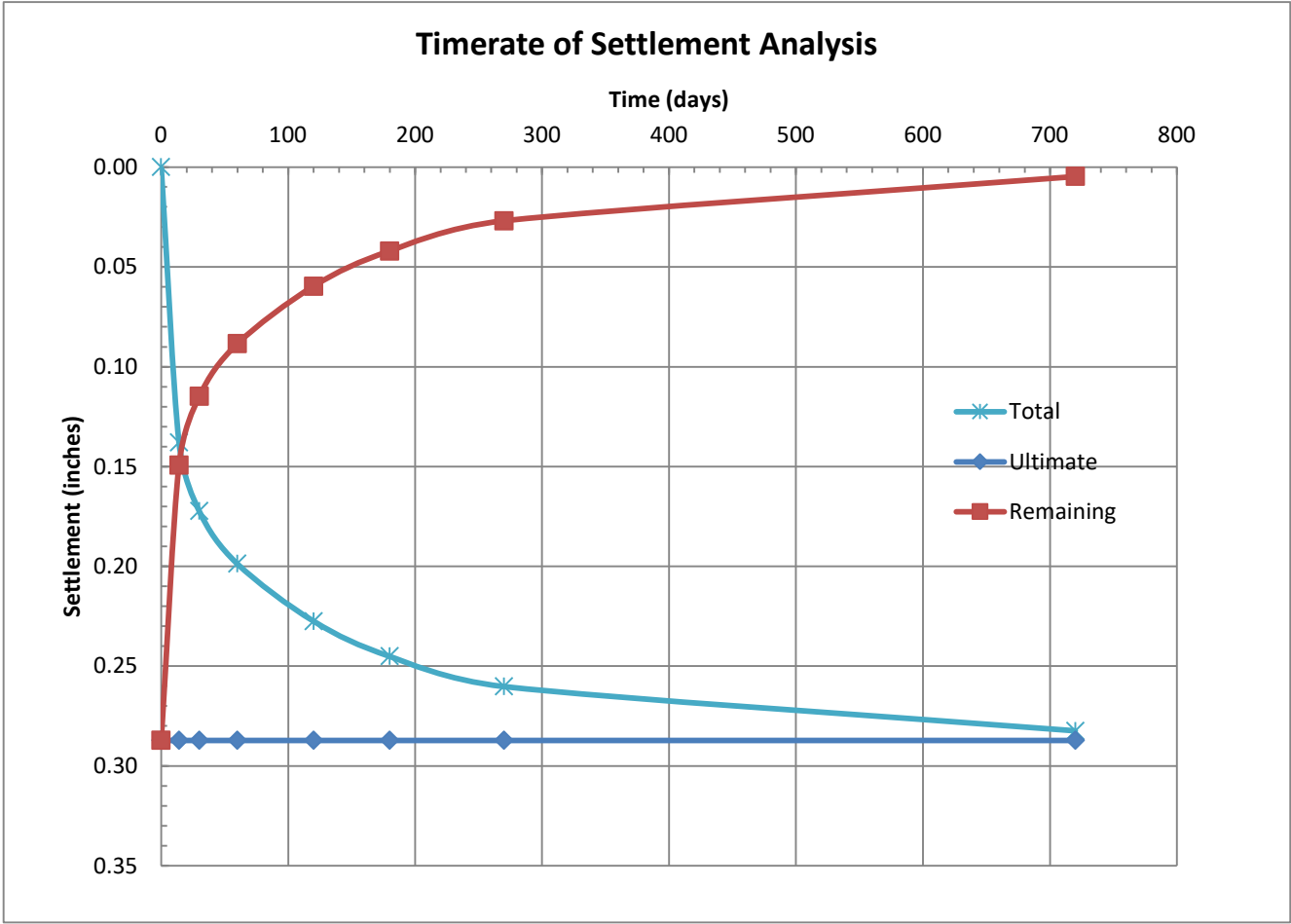
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TIME RATE OF SETTLEMENT

HDR Computation

Project:	HAM-126-19.50	Computed:	DCM	Date:	12/29/2024
Subject:	Sta. 2+93, 8.5 LT	Checked:	MM	Date:	1/6/2025
Task:	Settlement	Sheet:	2	of	2

Time	Total	Total	Ultimate	Remaining	%
days	Settlement (ft)	Settlement (inches)	Settlement (inches)	Settlement (inches)	Consolidation
0	0.00	0.00	0.29	0.29	0
14	0.01	0.14	0.29	0.15	48
30	0.01	0.17	0.29	0.11	60
60	0.02	0.20	0.29	0.09	69
120	0.02	0.23	0.29	0.06	79
180	0.02	0.25	0.29	0.04	85
270	0.02	0.26	0.29	0.03	91
720	0.02	0.28	0.29	0.00	98



Project: HAM-126-19.50
Subject: Sta. 2+93, 7.5 RT
Task: Settlement

Computed: <u>DCM</u>	Date: <u>12/29/2024</u>
Checked: <u>MM</u>	Date: <u>1/6/2025</u>
Rechecked: _____	Date: _____

2 OK

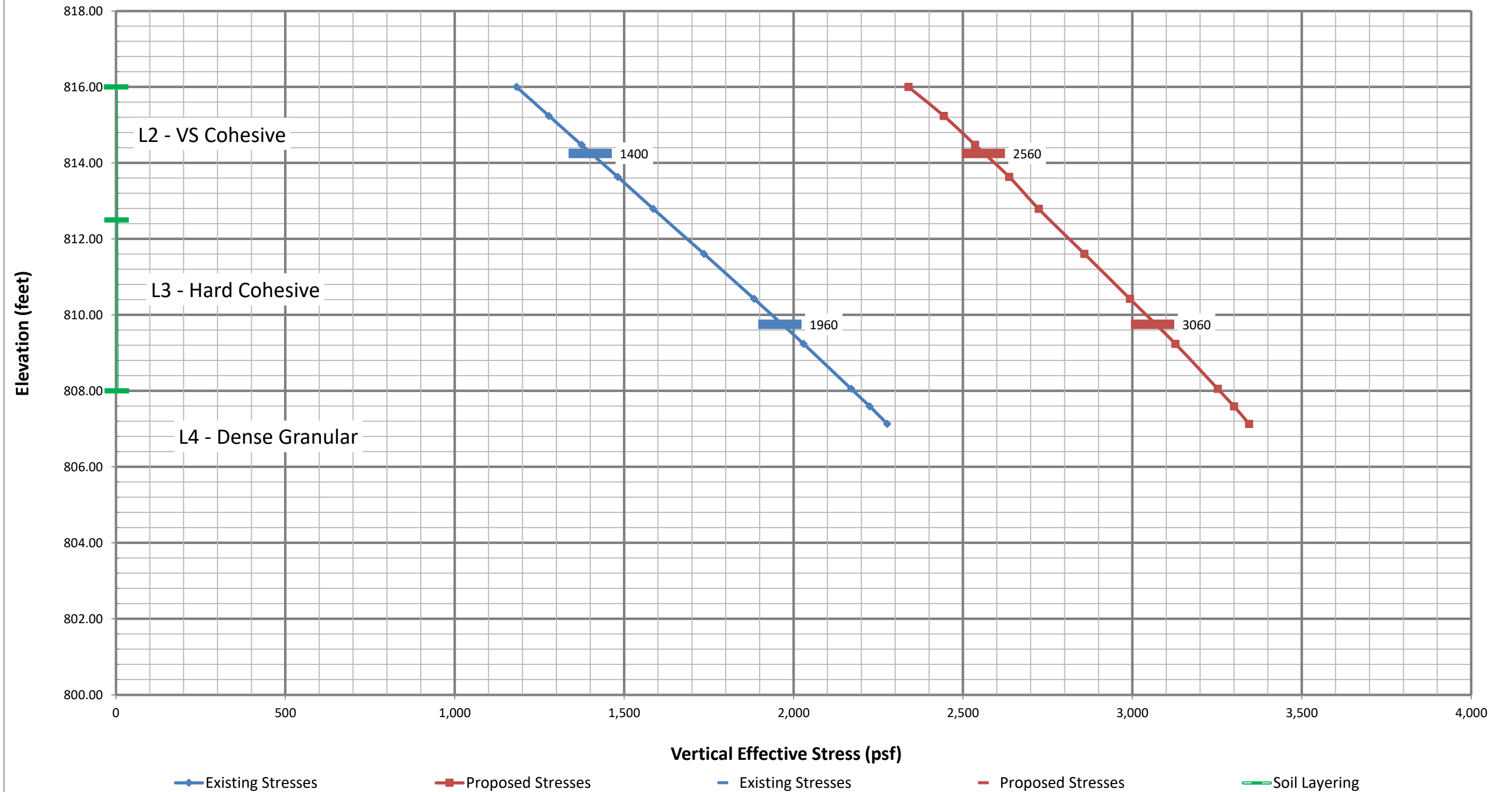
Journal Pre-proof

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HAM-126-19.50 - Pedestrian Bridge

Distribution of Vertical Effective Stress

Sta. 2+93 , 7.5 RT



HDR Computation

Project: HAM-126-19.50

Subject: Sta. 2+93, 7.5 RT

Task: Settlement

Normally Consolidated Soil

$$S = \sum \left[\frac{C_c}{1 + e_0} \cdot H \cdot \log \left(\frac{\sigma_f'}{\sigma_0'} \right) \right]$$

Overlyconsolidated Soil ($\sigma'_0 < \sigma'_p < \sigma_f$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma'_p}{\sigma_0} \right) + \frac{C_c}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma_f}{\sigma_p} \right) \right]$$

Cohesionless Soil Using Elastic Theory

$$S_e = \sum_{i=1}^n \Delta H_i$$

$$\Delta H_i = H_c \frac{1}{C'} \log \left(\frac{\sigma'_o + \Delta \sigma_v}{\sigma'_o} \right)$$

Overlyconsolidated Soil ($\sigma'_F < \sigma'_p$)

$$S = \sum \left[\frac{C_r}{1 + e_0} \cdot H \cdot \log \left(\frac{\sigma'_f}{\sigma'_0} \right) \right]$$

Soil Type		Top	Bottom	Thickness	Layers
L2 - VS Cohesive		816	812.5	3.5	1
L3 - Hard Cohesive		812.5	808	4.5	1
L4 - Dense Granular		808	807	1	0

S_e = total elastic (immediate) settlement
 n = number of soil layers within zone of stress influence of the footing
 H_i = Elastic (Immediate) settlement of Layer i (ft)
 H_c = Initial height of layer i (ft)
 C' = bearing capacity index from Figure 10.6.2.4.2-1
 (AASHTO LRFD Bridge Design Manual - 2012)
 $1 = N(C_N)$
 N_1 = SPT Blow count corrected for overburden pressure, σ'_v
 $C_N = [0.77 \log_{10} (40/\sigma'_v)]$, where $C_N < 2.0$

<u>Existing Ground Surface</u>	816	ft.
<u>Top of Drainage Layer</u>	816	ft.
<u>Bottom of Drainage Layer</u>	816	ft.

[illegible]

	0.025	ft
Total Settlement	0.30	in

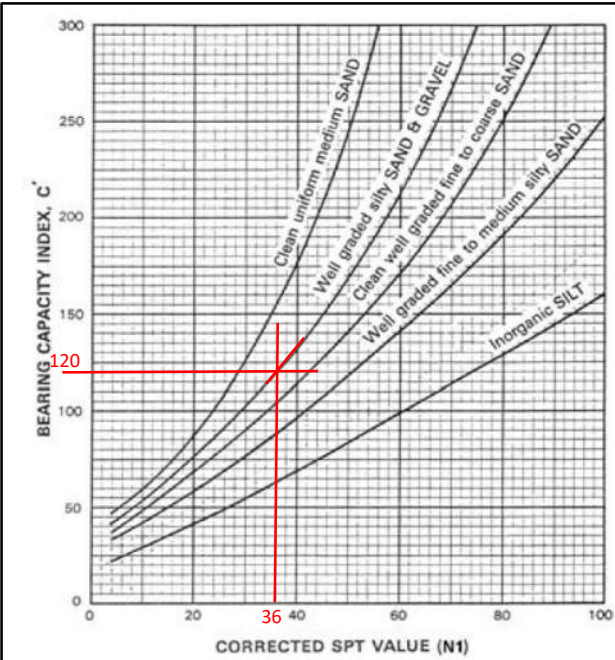


Figure 10.6.2.4.2-1—Bearing Capacity Index versus Corrected SPT (modified from Cheney and Chassie, 2000, after Hough, 1959)

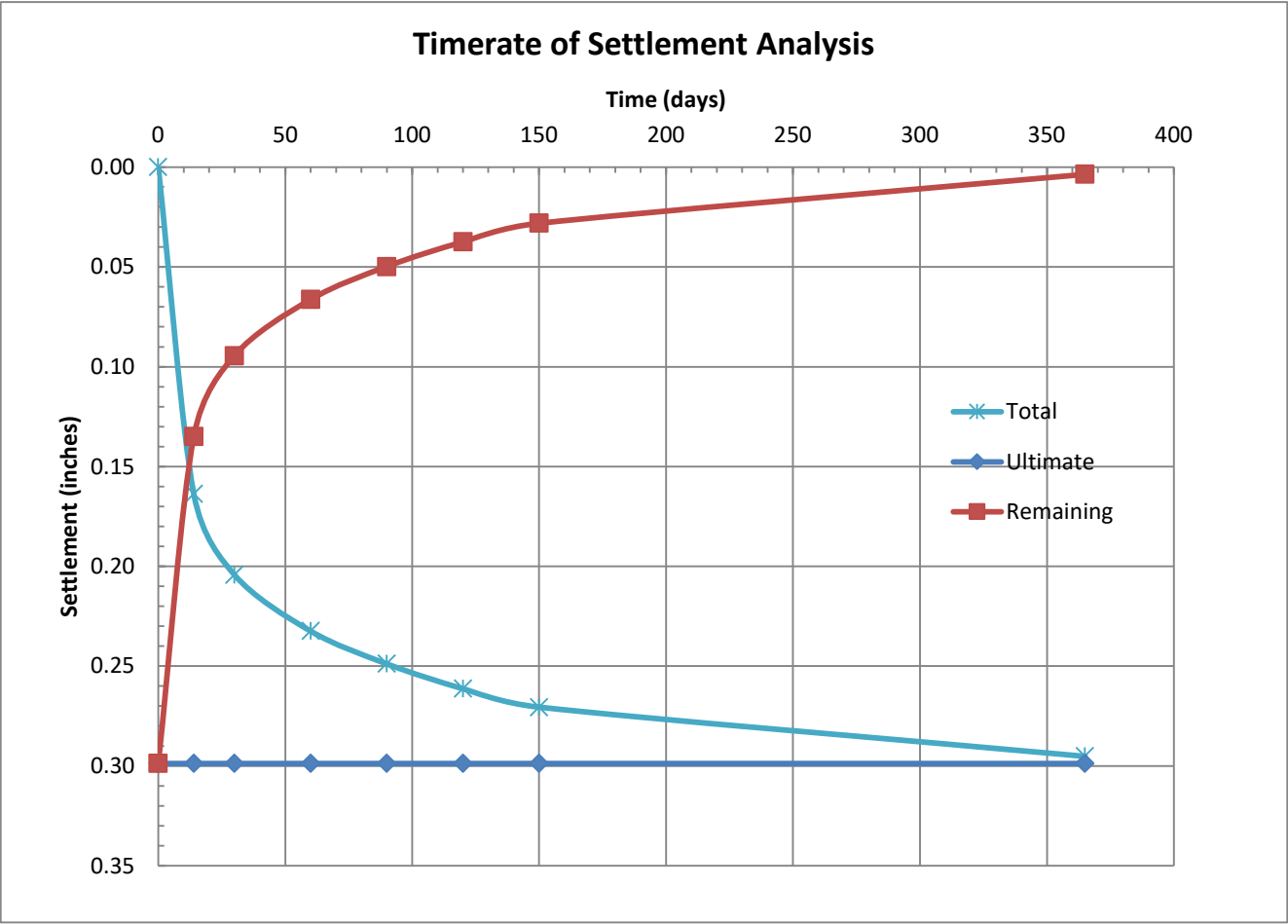
	Approximate Consolidation	
Consolidation	50%	91%
Time (days)	14	150
Time (Months)	0.5	5

TIME RATE OF SETTLEMENT

HDR Computation

Project:	HAM-126-19.50	Computed:	DCM	Date:	12/29/2024
Subject:	Sta. 2+93, 7.5 RT	Checked:	MM	Date:	1/6/2025
Task:	Settlement	Sheet:	2	of	2

Time	Total	Total	Ultimate	Remaining	%
days	Settlement (ft)	Settlement (inches)	Settlement (inches)	Settlement (inches)	Consolidation
0	0.00	0.00	0.30	0.30	0
14	0.01	0.16	0.30	0.13	55
30	0.02	0.20	0.30	0.09	68
60	0.02	0.23	0.30	0.07	78
90	0.02	0.25	0.30	0.05	83
120	0.02	0.26	0.30	0.04	87
150	0.02	0.27	0.30	0.03	91
365	0.02	0.30	0.30	0.00	99



Project: HAM-126-19.50

Subject: Sta. 2+93, 25 RT

Task: Settlement

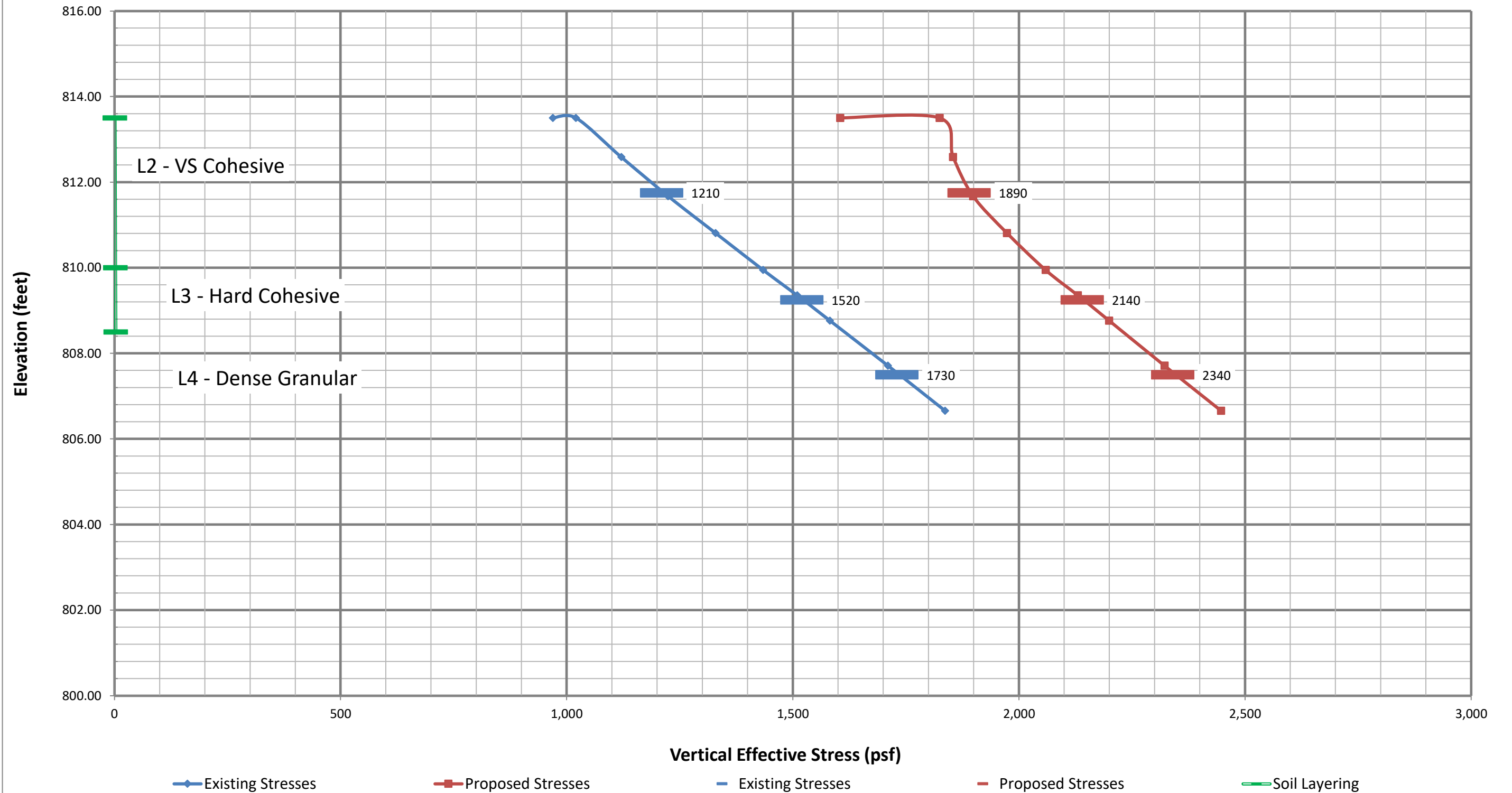
Soil Type	Top	Bottom	Thickness	Layers
L2 - VS Cohesive	813.5	810	3.5	1
L3 - Hard Cohesive	810	808.5	1.5	1
L4 - Dense Granular	808.5	806.5	2	0
Bedrock				

[illegible][illegible]

HAM-126-19.50 - Pedestrian Bridge

Distribution of Vertical Effective Stress

Sta. 2+93 , 25 RT



Project: HAM-126-19.50

Subject: Sta. 2+93, 25 RT

Task: Settlement

The graph plots the Bearing Capacity Index (C') on the vertical axis against the Corrected SPT Value (N_1) on the horizontal axis. The vertical axis ranges from 0 to 300 in increments of 50. The horizontal axis ranges from 0 to 100 in increments of 20. Five curves represent different soil types, with the following labels from top to bottom:

- Clean uniform medium SAND
- Well graded silty SAND & GRAVEL
- Clean well graded fine to coarse SAND
- Well graded fine to medium silty SAND
- Inorganic SILT

A red line is drawn across the graph at a Bearing Capacity Index of 120 and a Corrected SPT Value of 36, intersecting the 'Clean well graded fine to coarse SAND' curve.

	Approximate Consolidation	
Consolidation	50%	93%
Time (days)	30	150
Time (Months)	1.0	5

$$S = \sum \left[\frac{C_c}{1 + e_0} \cdot H \cdot \log \left(\frac{\sigma_f'}{\sigma_0'} \right) \right]$$

$$S = \sum \left[\frac{C_r}{1 + e_0} \cdot H \cdot \log \left(\frac{\sigma'_f}{\sigma'_0} \right) \right]$$

Cohesionless Soil Using Elastic Theory

$$S_e = \sum_{i=1}^n \Delta H_i$$

$$\Delta H_i = H_c \frac{1}{C'} \log \left(\frac{\sigma'_o + \Delta \sigma_v}{\sigma'_o} \right)$$

S_e = total elastic (immediate) settlement
 n = number of soil layers within zone of stress influence of the footing
 ΔH_i = Elastic (Immediate) settlement of Layer i (ft)
 H_c = Initial height of layer i (ft)
 C' = bearing capacity index from Figure 10.6.2.4.2-1
 (AASHTO LRFD Bridge Design Manual - 2012)
 $1 = N(C_N)$
 $N1$ = SPT Blow count corrected for overburden pressure, σ'_v
 $C_N = [0.77 \log_{10} (40/\sigma'_v)]$, where $C_N < 2.0$

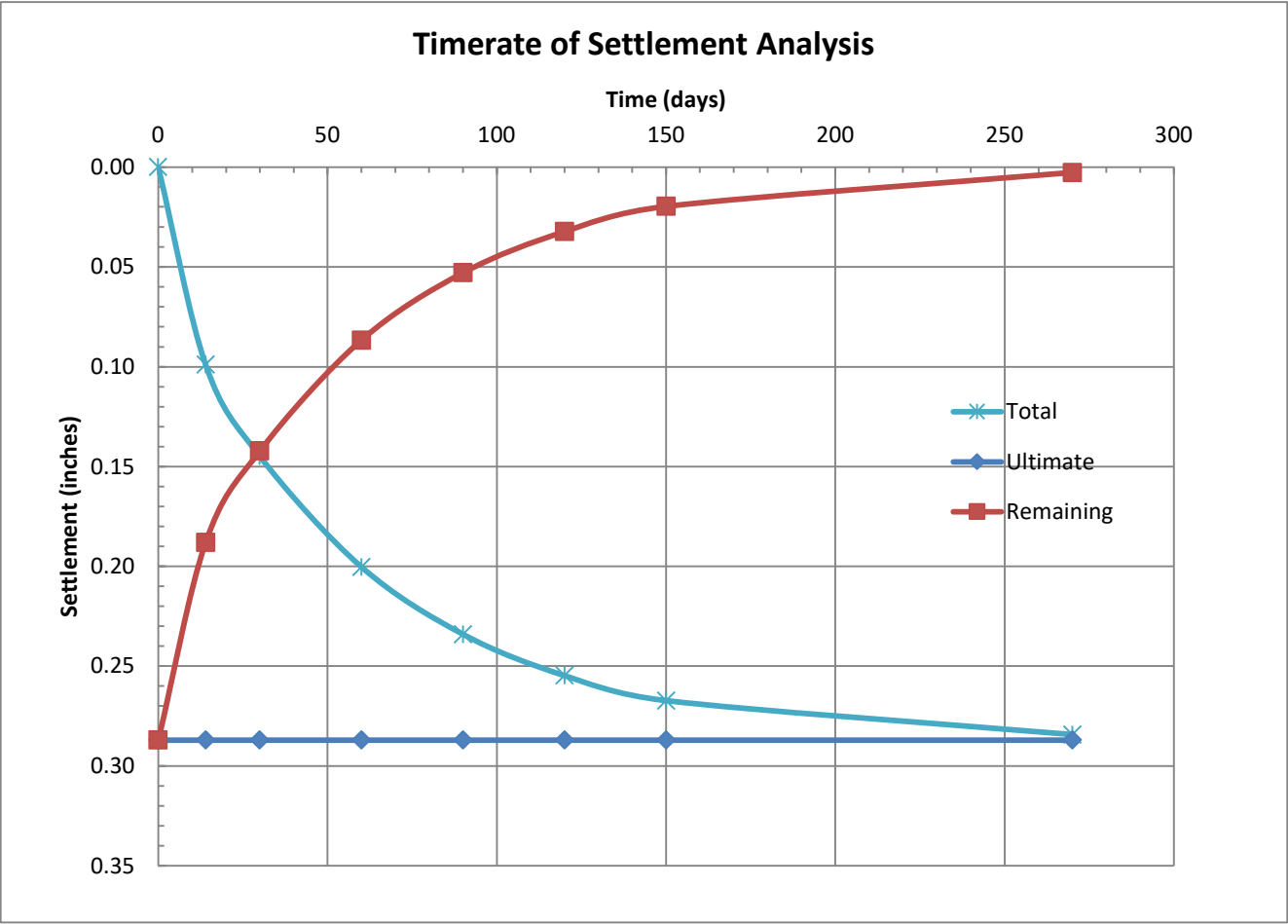
[illegible]

TIME RATE OF SETTLEMENT

HDR Computation

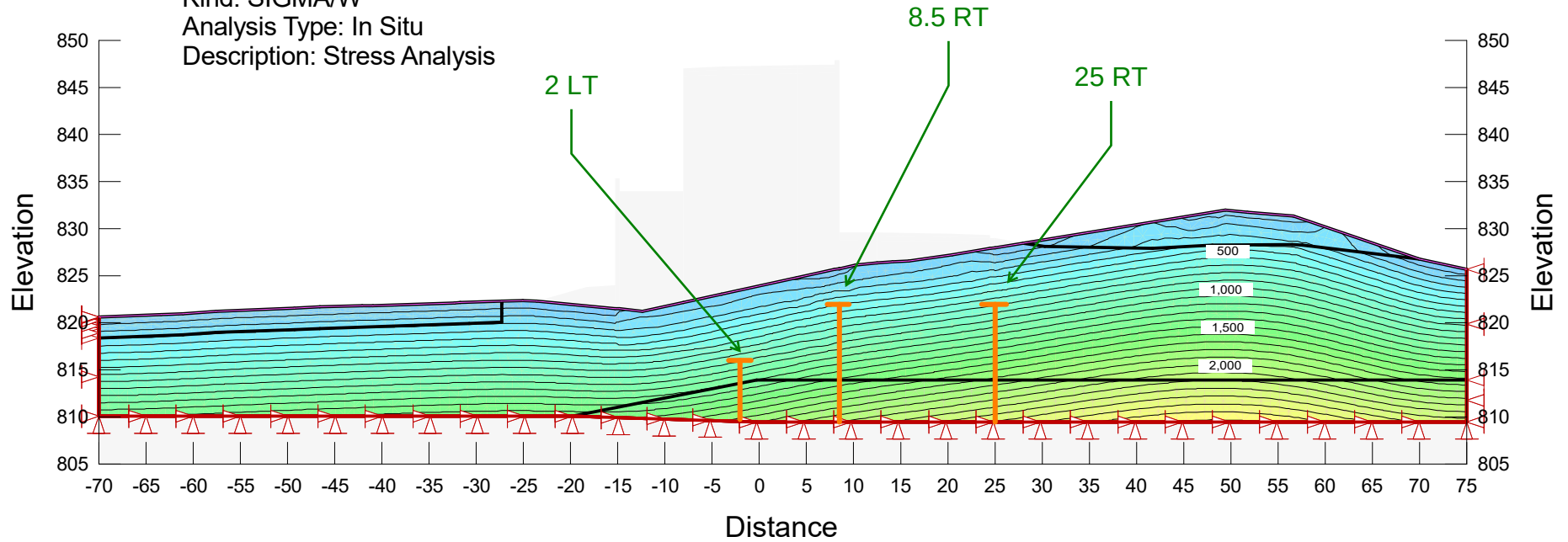
Project:	HAM-126-19.50	Computed:	DCM	Date:	12/29/2024
Subject:	Sta. 2+93, 25 RT	Checked:	MM	Date:	1/6/2025
Task:	Settlement	Sheet:	2	of	2

Time	Total	Total	Ultimate	Remaining	%
days	Settlement (ft)	Settlement (inches)	Settlement (inches)	Settlement (inches)	Consolidation
0	0.00	0.00	0.29	0.29	0
14	0.01	0.10	0.29	0.19	34
30	0.01	0.14	0.29	0.14	50
60	0.02	0.20	0.29	0.09	70
90	0.02	0.23	0.29	0.05	82
120	0.02	0.25	0.29	0.03	89
150	0.02	0.27	0.29	0.02	93
270	0.02	0.28	0.29	0.00	99



Settlement Analysis Locations

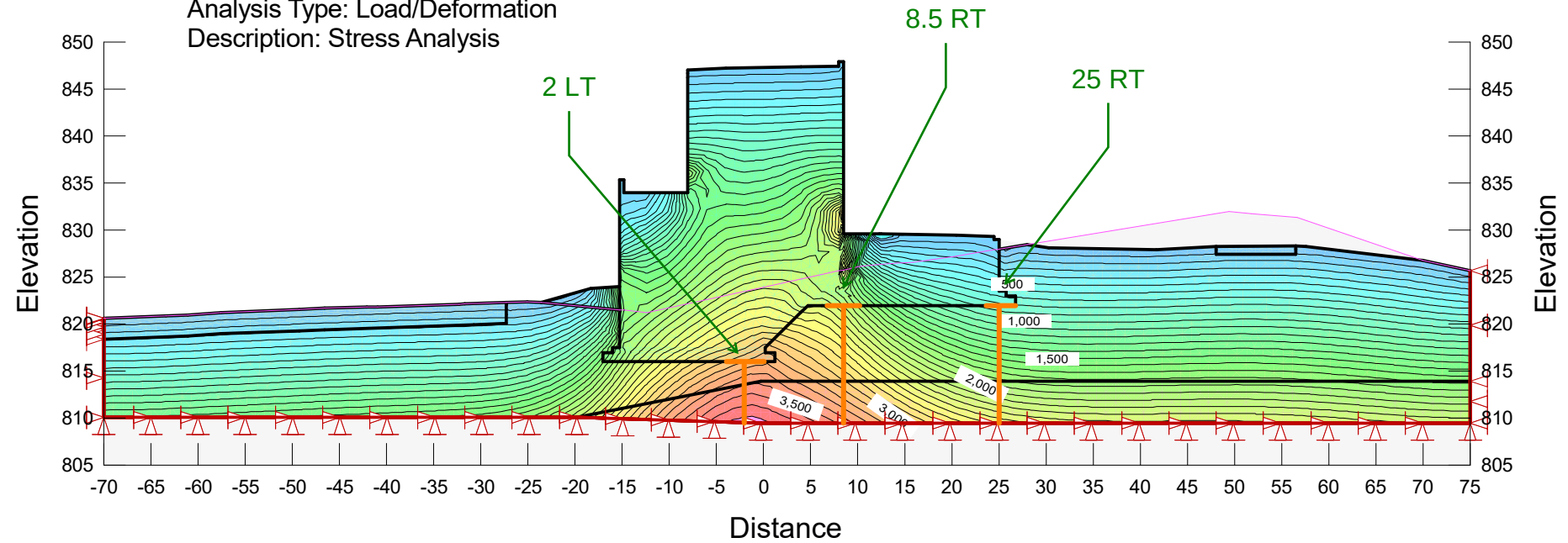
Name: 5+82_In Situ (3)
Kind: SIGMA/W
Analysis Type: In Situ
Description: Stress Analysis



Color	Name	Stress Material Model	Initial Void Ratio	Unit Weight (pcf)	Response Type	Effective Elastic Modulus (psf)	Effective Poisson's Ratio	Hydraulic Material Model
	Item 203 Embankment Fill (LT)	Isotropic Elastic	0.3	125	Drained	999,360	0.45	(none)
	Layer 2- Very Stiff Cohesive (LT)	Isotropic Elastic	0.58	130	Drained	1,199,520	0.45	(none)
	Layer 3- Hard Cohesive (LT)	Isotropic Elastic	0.58	130	Drained	2,000,160	0.45	(none)

Name: 5+82_Load/Deformation (3)
Kind: SIGMA/W
Analysis Type: Load/Deformation
Description: Stress Analysis

Settlement Analysis Locations



Color	Name	Stress Material Model	Initial Void Ratio	Unit Weight (pcf)	Response Type	Effective Elastic Modulus (psf)	Effective Poisson's Ratio	Hydraulic Material Model
■	High Strength	Isotropic Elastic	0.5	120	Drained	2,000,160	0.3	(none)
■	Item 203 Embankment Fill (LT)	Isotropic Elastic	0.3	125	Drained	999,360	0.45	(none)
■	Layer 2- Very Stiff Cohesive (LT)	Isotropic Elastic	0.58	130	Drained	1,199,520	0.45	(none)
■	Layer 3- Hard Cohesive (LT)	Isotropic Elastic	0.58	130	Drained	2,000,160	0.45	(none)

Project: HAM-126-19.50
Subject: Sta. 5+82, 2 L.T
Task: Settlement

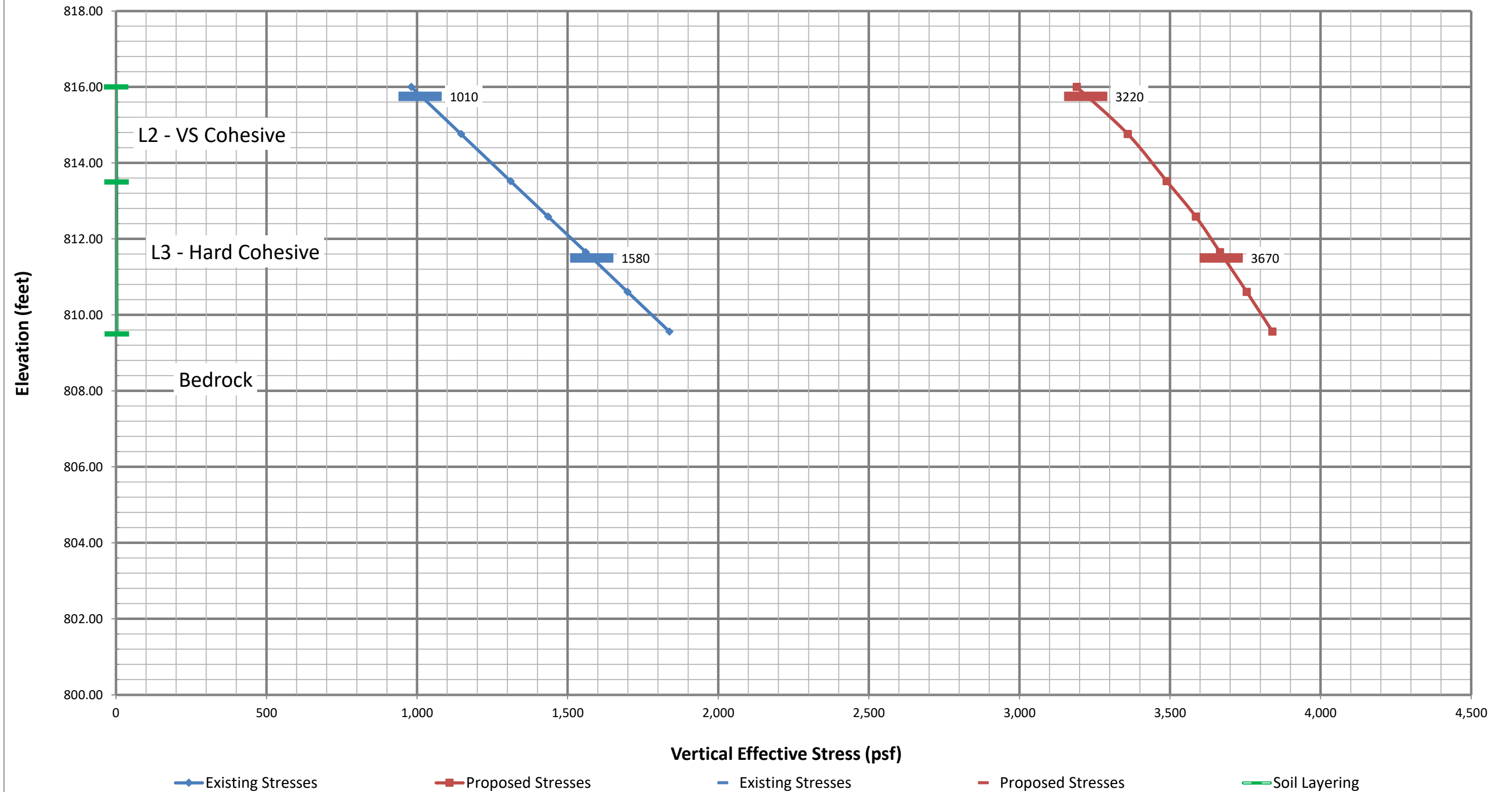
Soil Type	Top	Bottom	Thickness	Layers
L2 - VS Cohesive	816	813.5	2.5	1
L3 - Hard Cohesive	813.5	809.5	4	1
Bedrock	809.5		809.5	

[illegible][illegible]

HAM-126-19.50 - Pedestrian Bridge

Distribution of Vertical Effective Stress

Sta. 5+82 , 2 LT



HDR Computation

Project: HAM-126-19.50

Subject: Sta. 5+82, 2 LT

Task: Settlement

Normally Consolidated Soil

$$S = \sum \left[\frac{C_c}{1 + e_0} \cdot H \cdot \log \left(\frac{\sigma_f'}{\sigma_0'} \right) \right]$$

overlyconsolidated Soil ($\sigma'_0 < \sigma'_p < \sigma_f$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma'_p}{\sigma'_0} \right) + \frac{C_c}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma'_f}{\sigma'_p} \right) \right]$$

Cohesionless Soil Using Elastic Theory

$$S_e = \sum_{i=1}^n \Delta H_i$$

$$\Delta H_i = H_c \frac{1}{C'} \log \left(\frac{\sigma'_o + \Delta \sigma_v}{\sigma'_o} \right)$$

Overlyconsolidated Soil ($\sigma'_F < \sigma'_p$)

$$S = \sum \left[\frac{C_r}{1 + e_0} \cdot H \cdot \log \left(\frac{\sigma'_f}{\sigma'_0} \right) \right]$$

Soil Type	Top	Bottom	Thickness	Layers
L2 - VS Cohesive	816	813.5	2.5	1
L3 - Hard Cohesive	813.5	809.5	4	1
Bedrock	809.5	0	809.5	0

S_e = total elastic (immediate) settlement
 n = number of soil layers within zone of stress influence of the footing
 H_i = Elastic (Immediate) settlement of Layer i (ft)
 H_c = Initial height of layer i (ft)
 C' = bearing capacity index from Figure 10.6.2.4.2-1
 (AASHTO LRFD Bridge Design Manual - 2012)
 $1 = N(C_N)$
 $N1$ = SPT Blow count corrected for overburden pressure, σ'_v
 $C_N = [0.77 \log_{10} (40/\sigma'_v)]$, where $C_N < 2.0$

<u>Existing Ground Surface</u>	816	ft.
<u>Top of Drainage Layer</u>	816	ft.
<u>Bottom of Drainage Layer</u>	816	ft.

[illegible]

	0.015	ft
Total Settlement	0.18	in

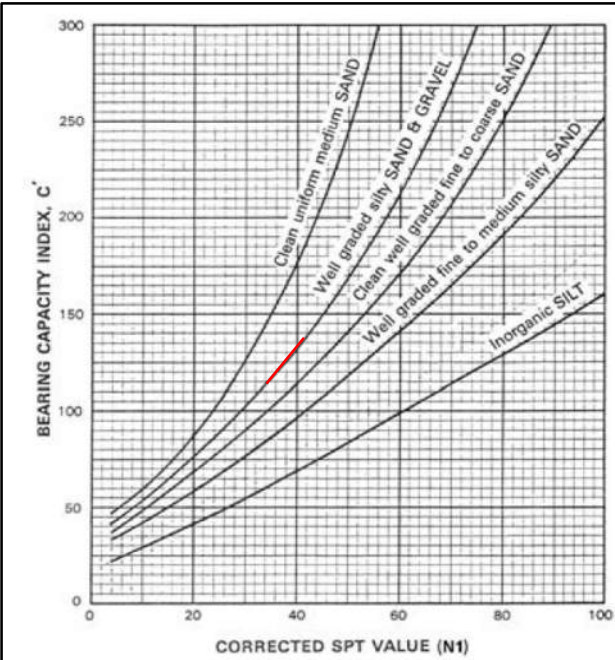


Figure 10.6.2.4.2-1—Bearing Capacity Index versus Corrected SPT (modified from Cheney and Chassie, 2000, after Hough, 1959)

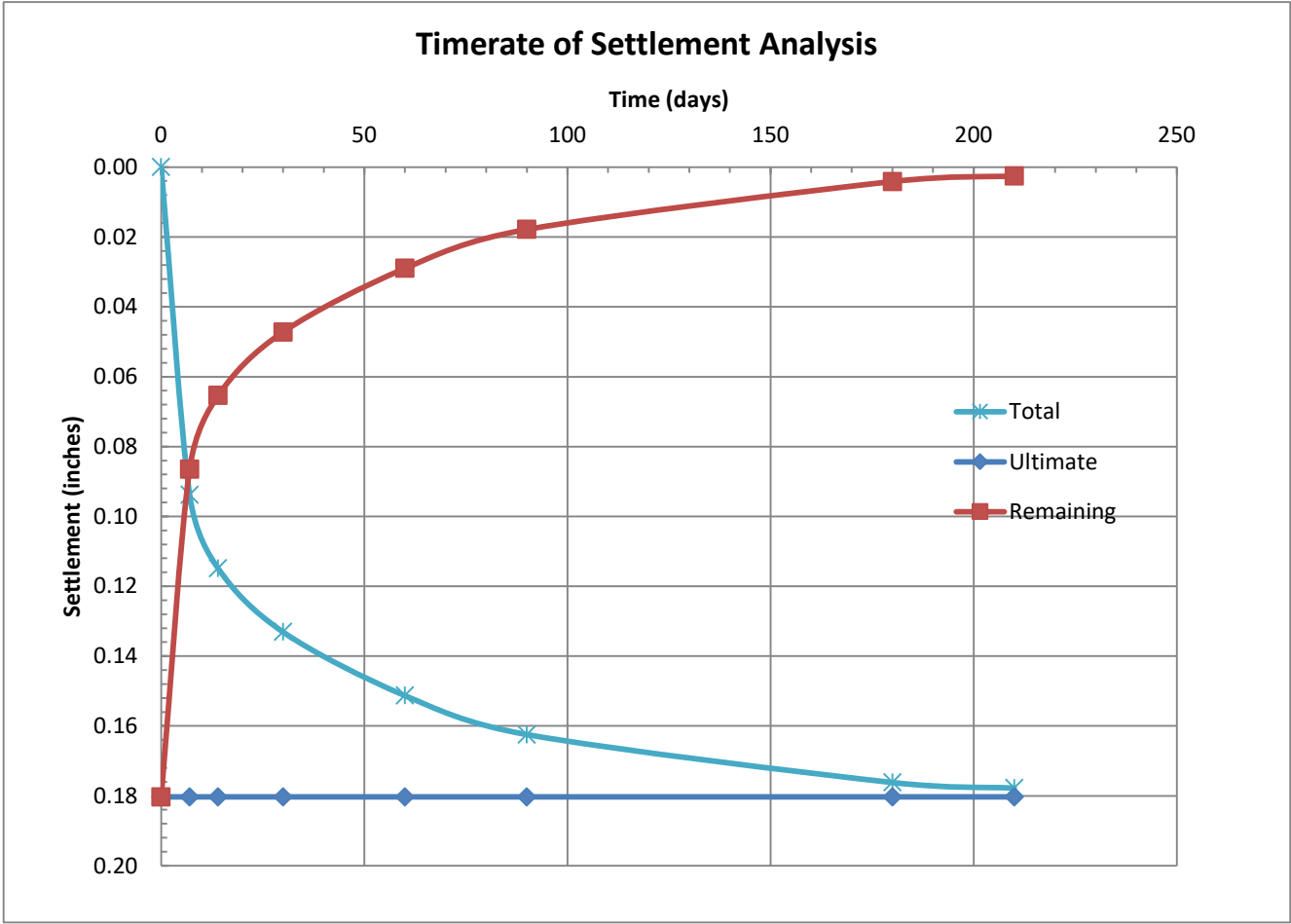
	Approximate Consolidation	
Consolidation	50%	90%
Time (days)	7	90
Time (Months)	0.2	3

TIME RATE OF SETTLEMENT

HDR Computation

Project:	HAM-126-19.50	Computed:	DCM	Date:	12/29/2024
Subject:	Sta. 5+82, 2 LT	Checked:	MM	Date:	1/7/2025
Task:	Settlement	Sheet:	2	of	2

Time	Total	Total	Ultimate	Remaining	%
days	Settlement (ft)	Settlement (inches)	Settlement (inches)	Settlement (inches)	Consolidation
0	0.00	0.00	0.18	0.18	0
7	0.01	0.09	0.18	0.09	52
14	0.01	0.11	0.18	0.07	64
30	0.01	0.13	0.18	0.05	74
60	0.01	0.15	0.18	0.03	84
90	0.01	0.16	0.18	0.02	90
180	0.01	0.18	0.18	0.00	98
210	0.01	0.18	0.18	0.00	99



Project: HAM-126-19.50

Subject: Sta. 5+82, 8.5 RT

Task: Settlement

Soil Type	Top	Bottom	Thickness	Layers
L2 - VS Cohesive	822	814	8	2
L3 - Hard Cohesive	814	809.5	4.5	1
Bedrock	809.5			

3

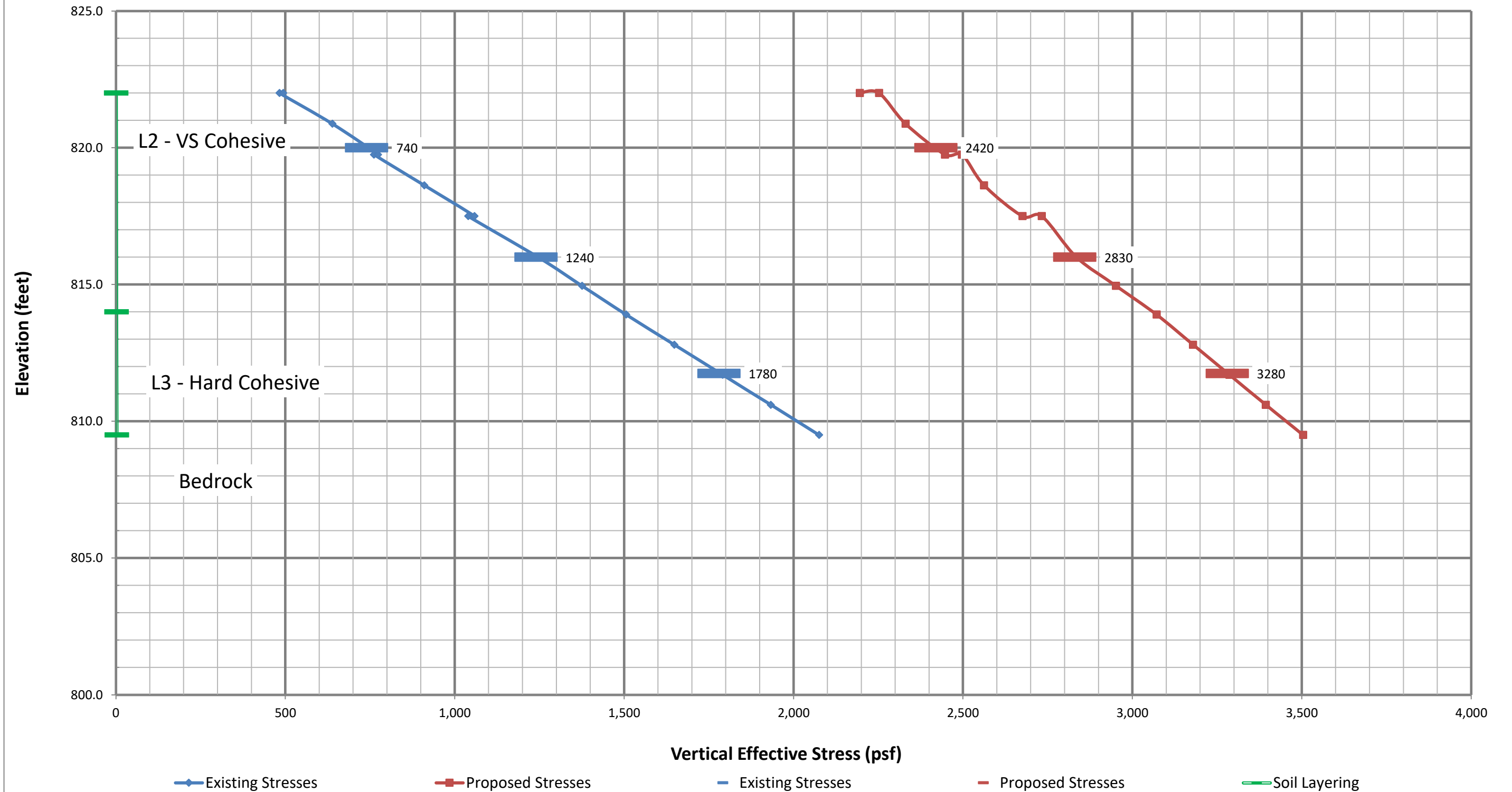
OK

[illegible]

HAM-126-19.50 - Pedestrian Bridge

Distribution of Vertical Effective Stress

Sta. 5+82 , 8.5 RT



HDR Computation

Project: HAM-126-19.50

Subject: Sta. 5+82, 8.5 RT

Task: Settlement

Normally Consolidated Soil

$$S = \sum \left[\frac{C_c}{1 + e_0} \cdot H \cdot \log \left(\frac{\sigma_f'}{\sigma_0'} \right) \right]$$

Overlyconsolidated Soil ($\sigma'_0 < \sigma'_p < \sigma_f$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma'_p}{\sigma'_0} \right) + \frac{C_c}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma'_f}{\sigma'_p} \right) \right]$$

Cohesionless Soil Using Elastic Theory

$$S_e = \sum_{i=1}^n \Delta H_i$$

$$\Delta H_i = H_c \frac{1}{C'} \log \left(\frac{\sigma'_o + \Delta \sigma_v}{\sigma'_o} \right)$$

Overlyconsolidated Soil ($\sigma'_F < \sigma'_P$)

$$S = \sum \left[\frac{C_r}{1 + e_0} \cdot H \cdot \log \left(\frac{\sigma'_f}{\sigma'_0} \right) \right]$$

Soil Type	Top	Bottom	Thickness	Layers
L2 - VS Cohesive	822	814	8	2
L3 - Hard Cohesive	814	809.5	4.5	1
Bedrock	809.5	0	0	0

S_e = total elastic (immediate) settlement
 n = number of soil layers within zone of stress influence of the footing
 H_i = Elastic (Immediate) settlement of Layer i (ft)
 H_c = Initial height of layer i (ft)
 C' = bearing capacity index from Figure 10.6.2.4.2-1
 (AASHTO LRFD Bridge Design Manual - 2012)
 $1 = N(C_N)$
 $N1$ = SPT Blow count corrected for overburden pressure, σ'_v
 $C_N = [0.77 \log_{10} (40/\sigma'_v)]$, where $C_N < 2.0$

[illegible]

	0.065	ft
Total Settlement	0.78	in

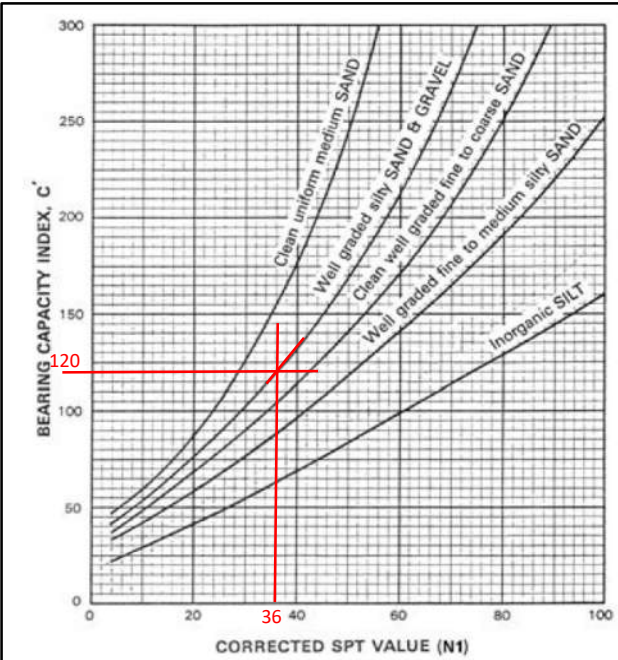


Figure 10.6.2.4.2-1—Bearing Capacity Index versus Corrected SPT (modified from Cheney and Chassie, 2000, after Hough, 1959)

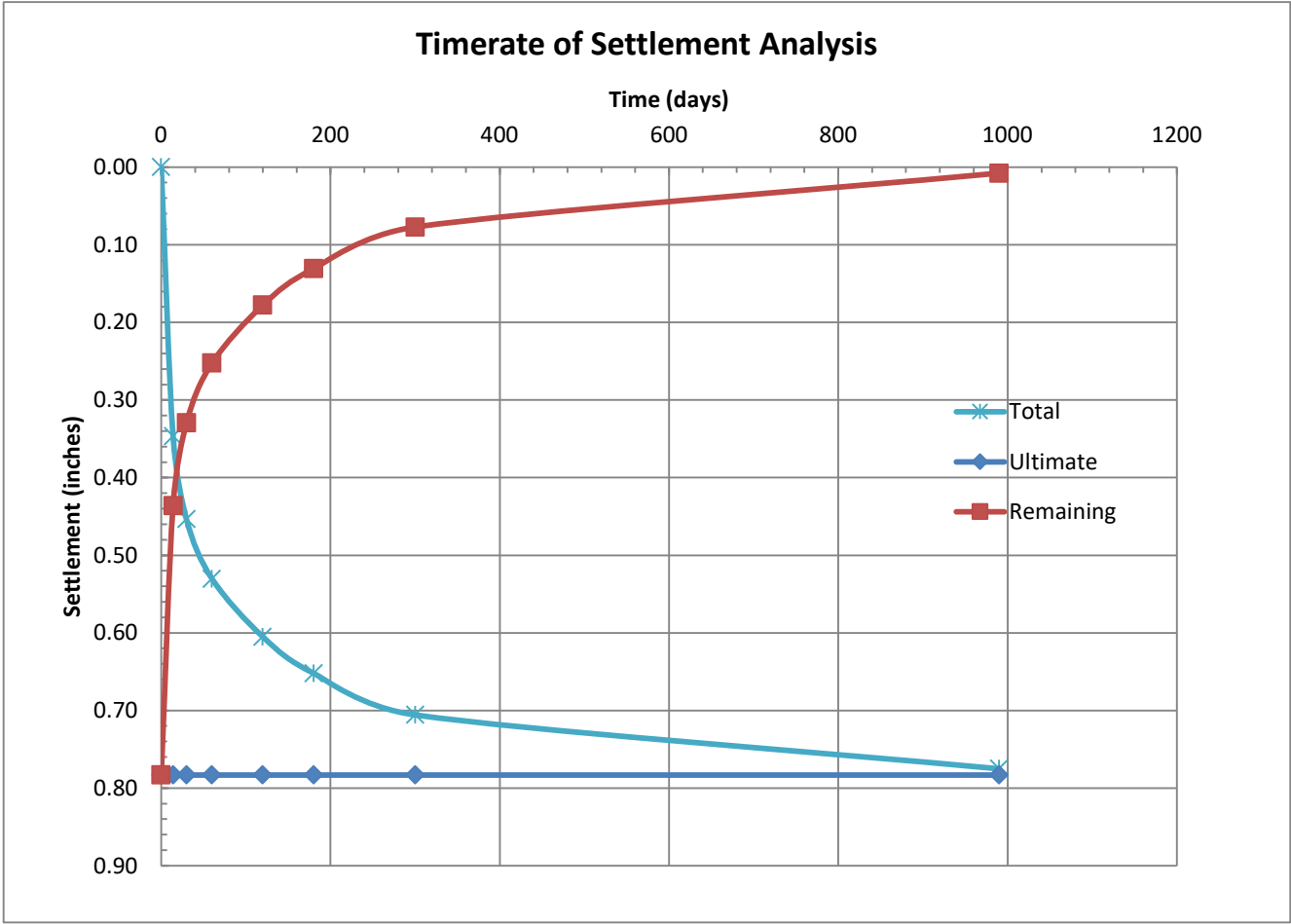
	Approximate Consolidation	
Consolidation	50%	90%
Time (days)	30	300
Time (Months)	1.0	10

TIME RATE OF SETTLEMENT

HDR Computation

Project:	HAM-126-19.50	Computed:	DCM	Date:	12/29/2024
Subject:	Sta. 5+82, 8.5 RT	Checked:	MM	Date:	1/8/2025
Task:	Settlement	Sheet:	2	of	2

Time	Total	Total	Ultimate	Remaining	%
days	Settlement (ft)	Settlement (inches)	Settlement (inches)	Settlement (inches)	Consolidation
0	0.00	0.00	0.78	0.78	0
14	0.03	0.35	0.78	0.44	44
30	0.04	0.45	0.78	0.33	58
60	0.04	0.53	0.78	0.25	68
120	0.05	0.61	0.78	0.18	77
180	0.05	0.65	0.78	0.13	83
300	0.06	0.71	0.78	0.08	90
990	0.06	0.78	0.78	0.01	99



Project: HAM-126-19.50

Subject: Sta. 5+82, 25 RT

Task: Settlement

Soil Type	Top	Bottom	Thickness	Layers
L2 - VS Cohesive	822	814	8	2
L3 - Hard Cohesive	814	809.5	4.5	1
Bedrock	809.5			

3

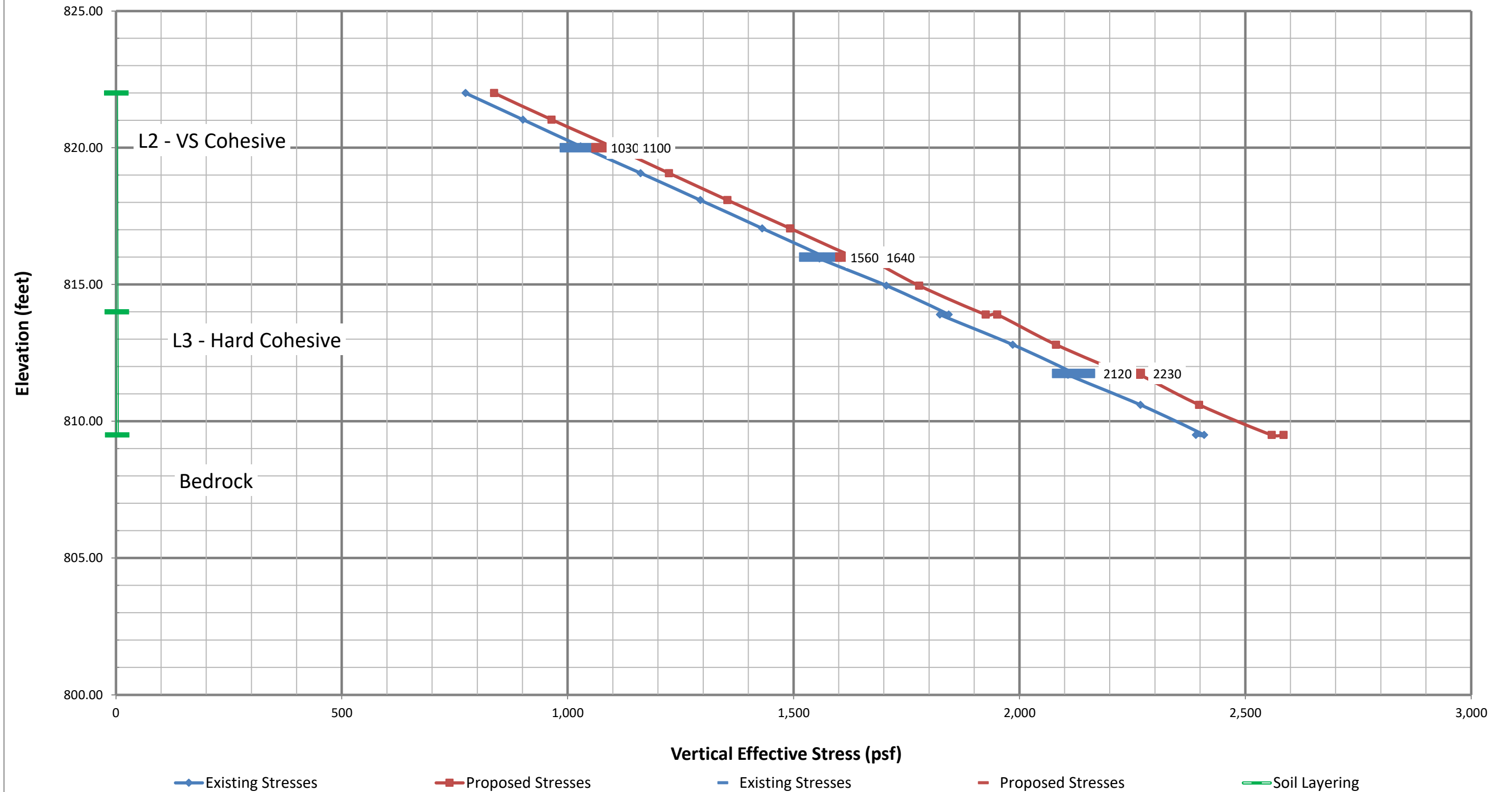
OK

[illegible]

HAM-126-19.50 - Pedestrian Bridge

Distribution of Vertical Effective Stress

Sta. 5+82 , 25 RT



Project: HAM-126-19.50

Subject: Sta. 5+82, 25 RT

Task: Settlement

The graph plots the Bearing Capacity Index (C') on the y-axis (0 to 300) against the Corrected SPT Value (N_1) on the x-axis (0 to 100). Five curves represent different soil types:

- Clean uniform medium SAND
- Well graded silty SAND & GRAVEL
- Clean well graded fine to coarse SAND
- Well graded fine to medium silty SAND
- Inorganic SILT

A red cross indicates a specific data point: $N_1 = 36$ and $C' = 120$, which falls on the 'Clean uniform medium SAND' curve.

	Approximate Consolidation	
Consolidation	50%	91%
Time (days)	30	300
Time (Months)	1.0	10

$$S = \sum \left[\frac{C_c}{1 + e_0} \cdot H \cdot \log \left(\frac{\sigma_f'}{\sigma_0'} \right) \right]$$
$$S = \sum \left[\frac{C_r}{1 + e_0} \cdot H \cdot \log \left(\frac{\sigma'_f}{\sigma'_0} \right) \right]$$
$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma'_p}{\sigma_0} \right) + \frac{C_c}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma'_f}{\sigma_p} \right) \right]$$

Soil Type	Top	Bottom	Thickness	Layers
L2 - VS Cohesive	822	814	8	2
L3 - Hard Cohesive	814	809.5	4.5	1
Bedrock	809.5	0	0	0

$$S_e = \sum_{i=1}^n \Delta H_i$$
$$\Delta H_i = H_c \frac{1}{C'} \log \left(\frac{\sigma'_o + \Delta \sigma_v}{\sigma'_o} \right)$$

S_e = total elastic (immediate) settlement
 n = number of soil layers within zone of stress influence of the footing
 ΔH_i = Elastic (Immediate) settlement of Layer i (ft)
 H_c = Initial height of layer i (ft)
 C' = bearing capacity index from Figure 10.6.2.4.2-1
 (AASHTO LRFD Bridge Design Manual - 2012)
 $1 = N(C_N)$
 $N1$ = SPT Blow count corrected for overburden pressure, σ'_v
 $C_N = [0.77 \log_{10} (40/\sigma'_v)]$, where $C_N < 2.0$

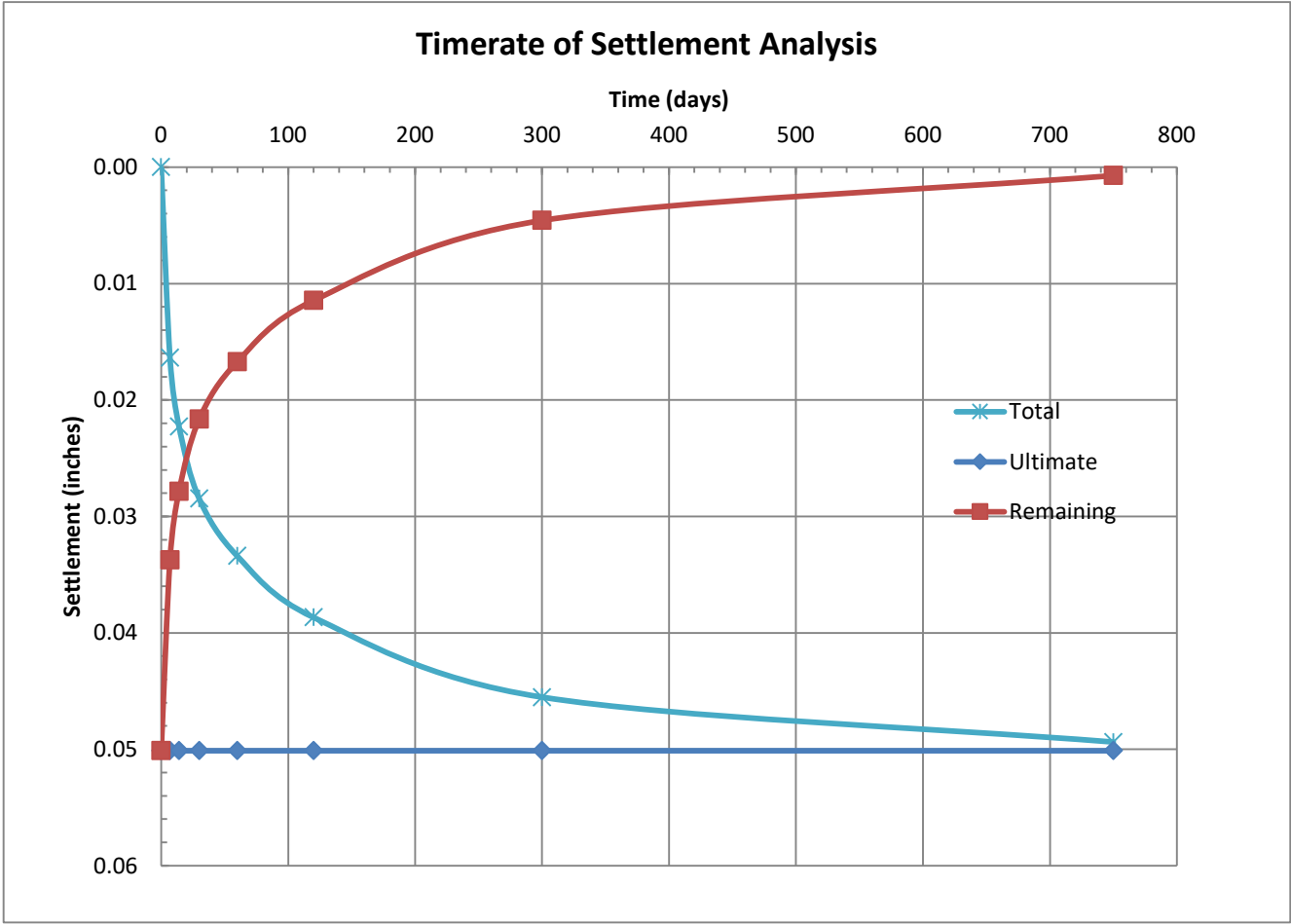
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TIME RATE OF SETTLEMENT

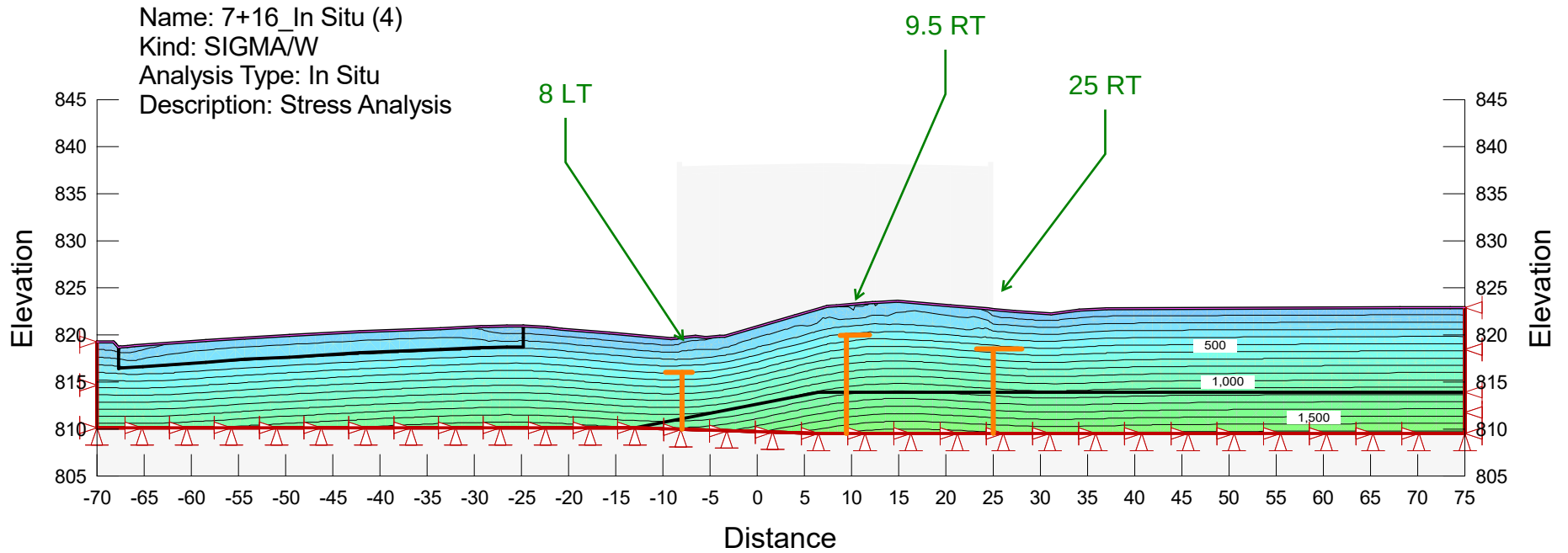
HDR Computation

Project:	HAM-126-19.50	Computed:	DCM	Date:	12/29/2024
Subject:	Sta. 5+82, 25 RT	Checked:	MM	Date:	1/8/2025
Task:	Settlement	Sheet:	2	of	2

Time	Total	Total	Ultimate	Remaining	%
days	Settlement (ft)	Settlement (inches)	Settlement (inches)	Settlement (inches)	Consolidation
0	0.00	0.00	0.05	0.05	0
7	0.00	0.02	0.05	0.03	33
14	0.00	0.02	0.05	0.03	44
30	0.00	0.03	0.05	0.02	57
60	0.00	0.03	0.05	0.02	67
120	0.00	0.04	0.05	0.01	77
300	0.00	0.05	0.05	0.00	91
750	0.00	0.05	0.05	0.00	99



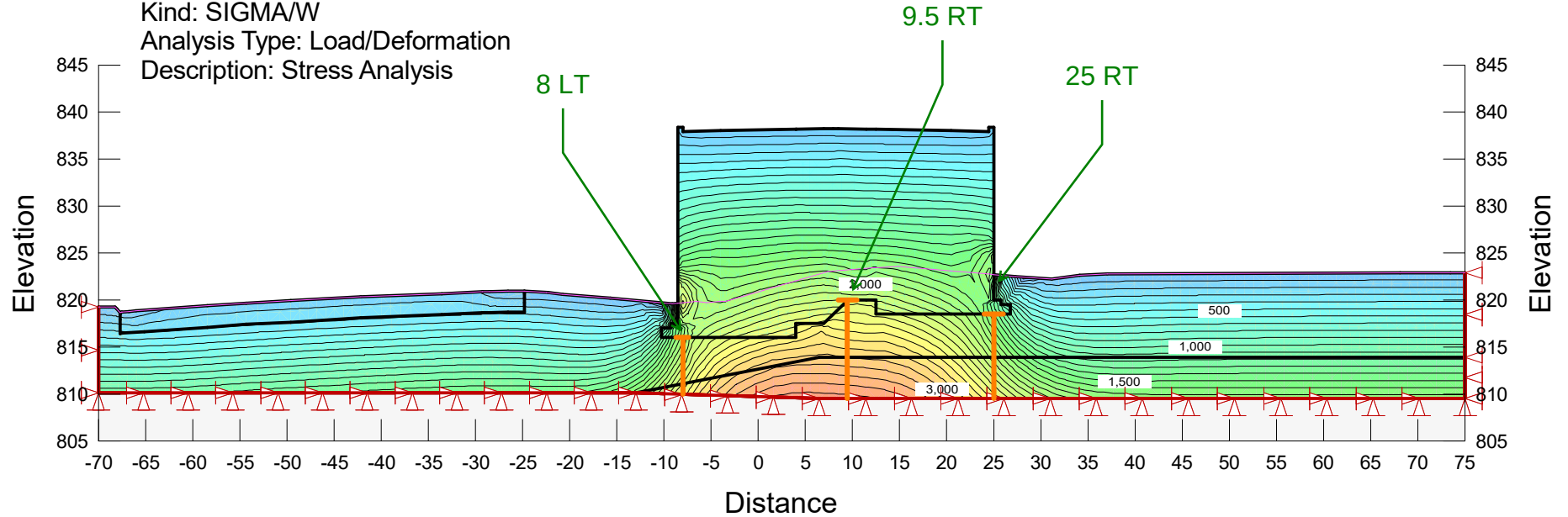
Settlement Analysis Locations



Color	Name	Stress Material Model	Initial Void Ratio	Unit Weight (pcf)	Response Type	Effective Elastic Modulus (psf)	Effective Poisson's Ratio	Hydraulic Material Model
	Item 203 Embankment Fill (LT)	Isotropic Elastic	0.3	125	Drained	999,360	0.45	(none)
	Layer 2- Very Stiff Cohesive (LT)	Isotropic Elastic	0.58	130	Drained	1,199,520	0.45	(none)
	Layer 3- Hard Cohesive (LT)	Isotropic Elastic	0.58	130	Drained	2,000,160	0.45	(none)

Settlement Analysis Locations

Name: 7+16_Load/Deformation (4)
 Kind: SIGMA/W
 Analysis Type: Load/Deformation
 Description: Stress Analysis



Color	Name	Stress Material Model	Initial Void Ratio	Unit Weight (pcf)	Response Type	Effective Elastic Modulus (psf)	Effective Poisson's Ratio	Hydraulic Material Model
	High Strength	Isotropic Elastic	0.5	120	Drained	2,000,160	0.3	(none)
	Item 203 Embankment Fill (LT)	Isotropic Elastic	0.3	125	Drained	999,360	0.45	(none)
	Layer 2- Very Stiff Cohesive (LT)	Isotropic Elastic	0.58	130	Drained	1,199,520	0.45	(none)
	Layer 3- Hard Cohesive (LT)	Isotropic Elastic	0.58	130	Drained	2,000,160	0.45	(none)

Project: HAM-126-19.50

Subject: Sta. 7+16, 8 LT

Task: Settlement

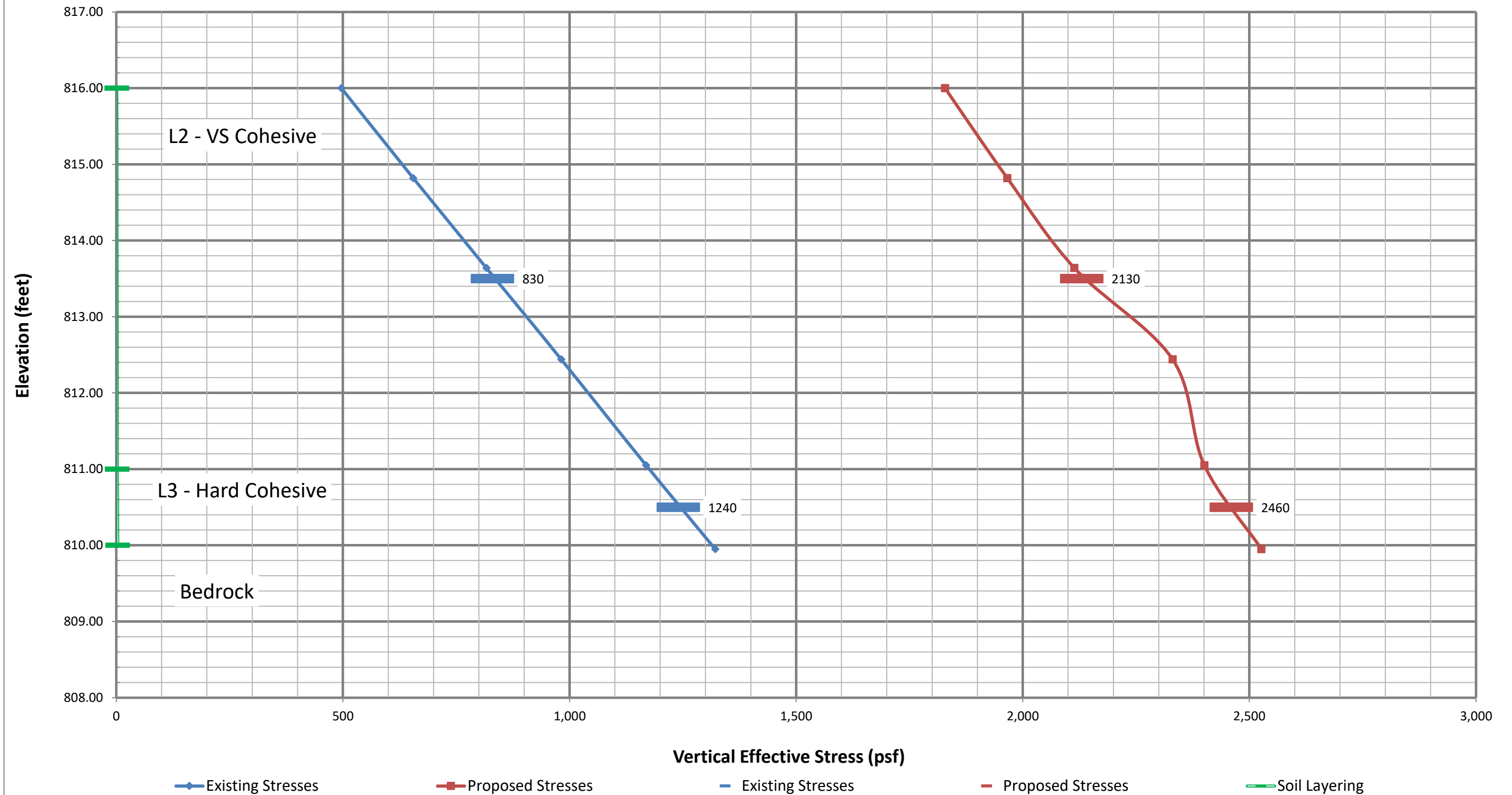
Soil Type	Top	Bottom	Thickness	Layers
L2 - VS Cohesive	816	811	5	1
L3 - Hard Cohesive	811	810	1	1
Bedrock	810		810	

[illegible][illegible]

HAM-126-19.50 - Pedestrian Bridge

Distribution of Vertical Effective Stress

Sta. 7+16 , 8 LT



HDR Computation

Project: HAM-126-19.50

Subject: Sta. 7+16, 8 LT

Task: Settlement

Normally Consolidated Soil

$$S = \sum \left[\frac{C_c}{1 + e_0} \cdot H \cdot \log \left(\frac{\sigma_f'}{\sigma_0'} \right) \right]$$

Overlyconsolidated Soil ($\sigma'_0 < \sigma'_p < \sigma_f$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma'_p}{\sigma_0} \right) + \frac{C_c}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma'_f}{\sigma_p} \right) \right]$$

Cohesionless Soil Using Elastic Theory

$$S_e = \sum_{i=1}^n \Delta H_i$$

$$\Delta H_i = H_c \frac{1}{C'} \log \left(\frac{\sigma'_o + \Delta \sigma_v}{\sigma'_o} \right)$$

Overlyconsolidated Soil ($\sigma'_F < \sigma'_p$)

$$S = \sum \left[\frac{C_r}{1 + e_0} \cdot H \cdot \log \left(\frac{\sigma'_f}{\sigma'_0} \right) \right]$$

Soil Type	Top	Bottom	Thickness	Layers
L2 - VS Cohesive	816	811	5	1
L3 - Hard Cohesive	811	810	1	1
Bedrock	810	0	810	0

S_e = total elastic (immediate) settlement
 n = number of soil layers within zone of stress influence of the footing
 H_i = Elastic (Immediate) settlement of Layer i (ft)
 H_c = Initial height of layer i (ft)
 C' = bearing capacity index from Figure 10.6.2.4.2-1
 (AASHTO LRFD Bridge Design Manual - 2012)
 $1 = N(C_N)$
 N_1 = SPT Blow count corrected for overburden pressure, σ'_v
 $C_N = [0.77 \log_{10} (40/\sigma'_v)]$, where $C_N < 2.0$

<u>Existing Ground Surface</u>	816	ft.
<u>Top of Drainage Layer</u>	816	ft.
<u>Bottom of Drainage Layer</u>	816	ft.

[illegible]

	0.033	ft
Total Settlement	0.39	in

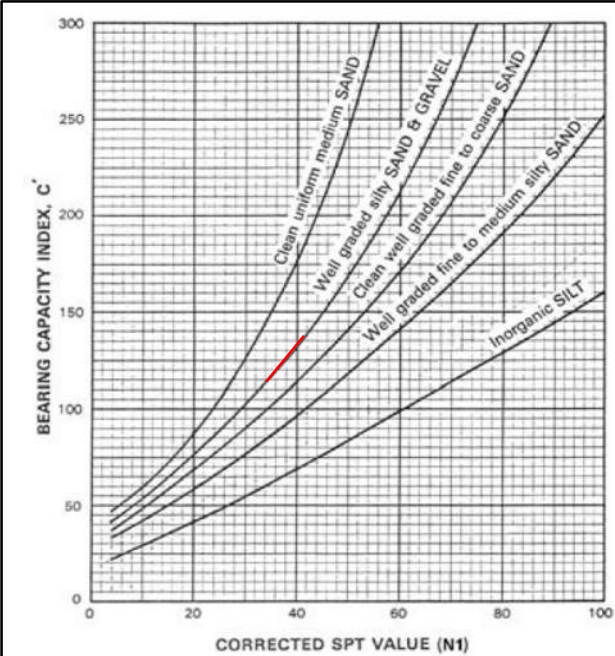


Figure 10.6.2.4.2-1—Bearing Capacity Index versus Corrected SPT (modified from Cheney and Chassie, 2000, after Hough, 1959)

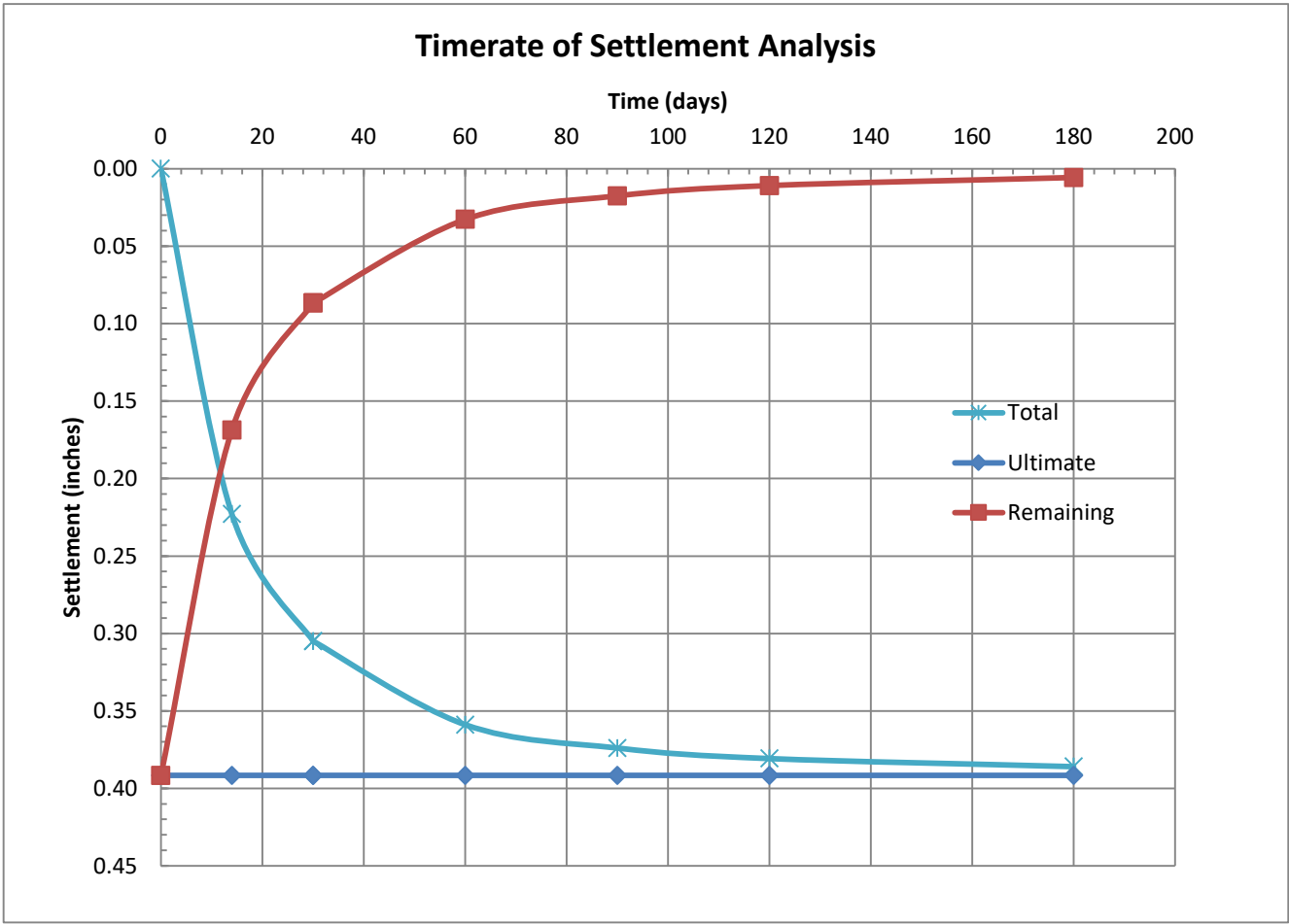
	Approximate Consolidation	
Consolidation	50%	92%
Time (days)	14	60
Time (Months)	0.5	2

TIME RATE OF SETTLEMENT

HDR Computation

Project:	HAM-126-19.50	Computed:	DCM	Date:	12/29/2024
Subject:	Sta. 7+16, 8 LT	Checked:	MM	Date:	1/6/2025
Task:	Settlement	Sheet:	2	of	2

Time	Total	Total	Ultimate	Remaining	%
days	Settlement (ft)	Settlement (inches)	Settlement (inches)	Settlement (inches)	Consolidation
0	0.00	0.00	0.39	0.39	0
14	0.02	0.22	0.39	0.17	57
30	0.03	0.30	0.39	0.09	78
30	0.03	0.30	0.39	0.09	78
60	0.03	0.36	0.39	0.03	92
90	0.03	0.37	0.39	0.02	95
120	0.03	0.38	0.39	0.01	97
180	0.03	0.39	0.39	0.01	99



Project: HAM-126-19.50

Subject: Sta. 7+16, 9.5 RT

Task: Settlement

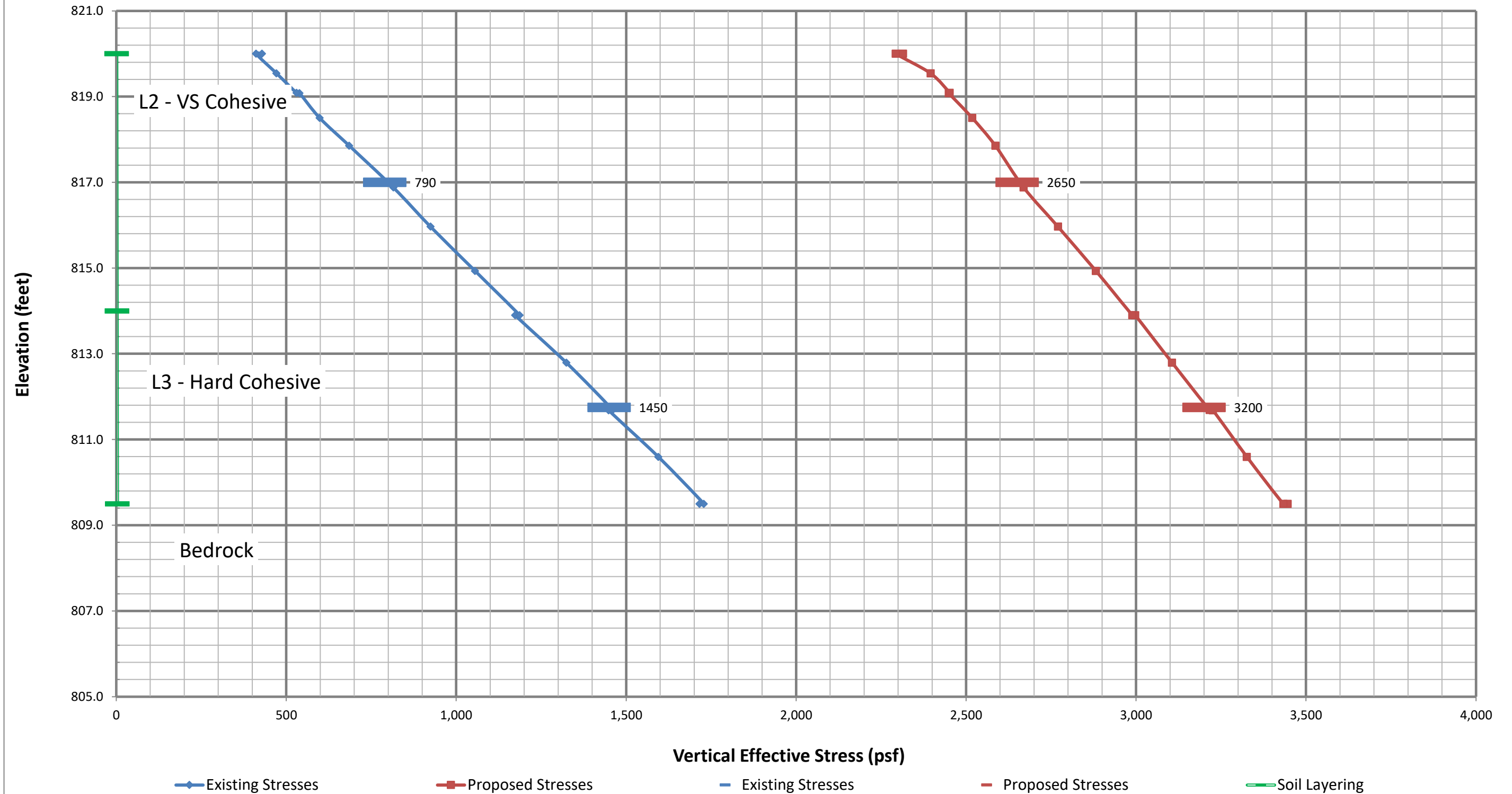
Soil Type	Top	Bottom	Thickness	Layers
L2 - VS Cohesive	820	814	6	1
L3 - Hard Cohesive	814	809.5	4.5	1
Bedrock	809.5			

[illegible]

HAM-126-19.50 - Pedestrian Bridge

Distribution of Vertical Effective Stress

Sta. 7+16 , 9.5 RT



HDR Computation

Project: HAM-126-19.50

Subject: Sta. 7+16, 9.5 RT

Task: Settlement

Normally Consolidated Soil

$$S = \sum \left[\frac{C_c}{1 + e_0} \cdot H \cdot \log \left(\frac{\sigma_f'}{\sigma_0'} \right) \right]$$

Overlyconsolidated Soil ($\sigma'_0 < \sigma'_p < \sigma_f$)

$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma'_p}{\sigma_0} \right) + \frac{C_c}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma_f}{\sigma_p} \right) \right]$$

Cohesionless Soil Using Elastic Theory

$$S_e = \sum_{i=1}^n \Delta H_i$$

$$\Delta H_i = H_c \frac{1}{C'} \log \left(\frac{\sigma'_o + \Delta \sigma_v}{\sigma'_o} \right)$$

Overlyconsolidated Soil ($\sigma'_F < \sigma'_p$)

$$S = \sum \left[\frac{C_r}{1 + e_0} \cdot H \cdot \log \left(\frac{\sigma'_f}{\sigma'_0} \right) \right]$$

Soil Type	Top	Bottom	Thickness	Layers
L2 - VS Cohesive	820	814	6	1
L3 - Hard Cohesive	814	809.5	4.5	1
Bedrock	809.5	0	0	0

S_e = total elastic (immediate) settlement
 n = number of soil layers within zone of stress influence of the footing
 H_i = Elastic (Immediate) settlement of Layer i (ft)
 H_c = Initial height of layer i (ft)
 C' = bearing capacity index from Figure 10.6.2.4.2-1
 (AASHTO LRFD Bridge Design Manual - 2012)
 $1 = N(C_N)$
 $N1$ = SPT Blow count corrected for overburden pressure, σ'_v
 $C_N = [0.77 \log_{10} (40/\sigma'_v)]$, where $C_N < 2.0$

<u>Existing Ground Surface</u>	820	ft.
<u>Top of Drainage Layer</u>	820	ft.
<u>Bottom of Drainage Layer</u>	802	ft.

[illegible]

	0.065	ft
Total Settlement	0.79	in

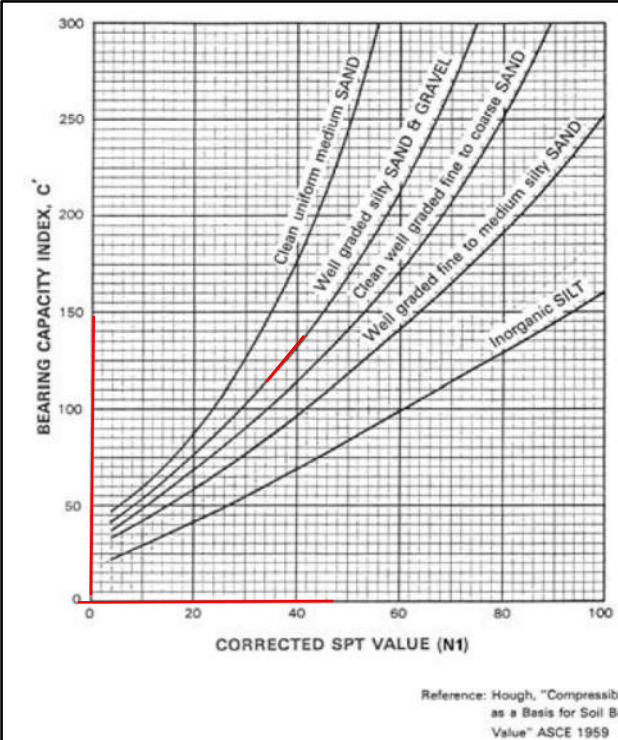


Figure 10.6.2.4.2-1—Bearing Capacity Index versus Corrected SPT (modified from Cheney and Chassie, 2000, after Hough, 1959)

	Approximate Consolidation	
Consolidation	50%	90%
Time (days)	30	210
Time (Months)	1.0	7

TIME RATE OF SETTLEMENT

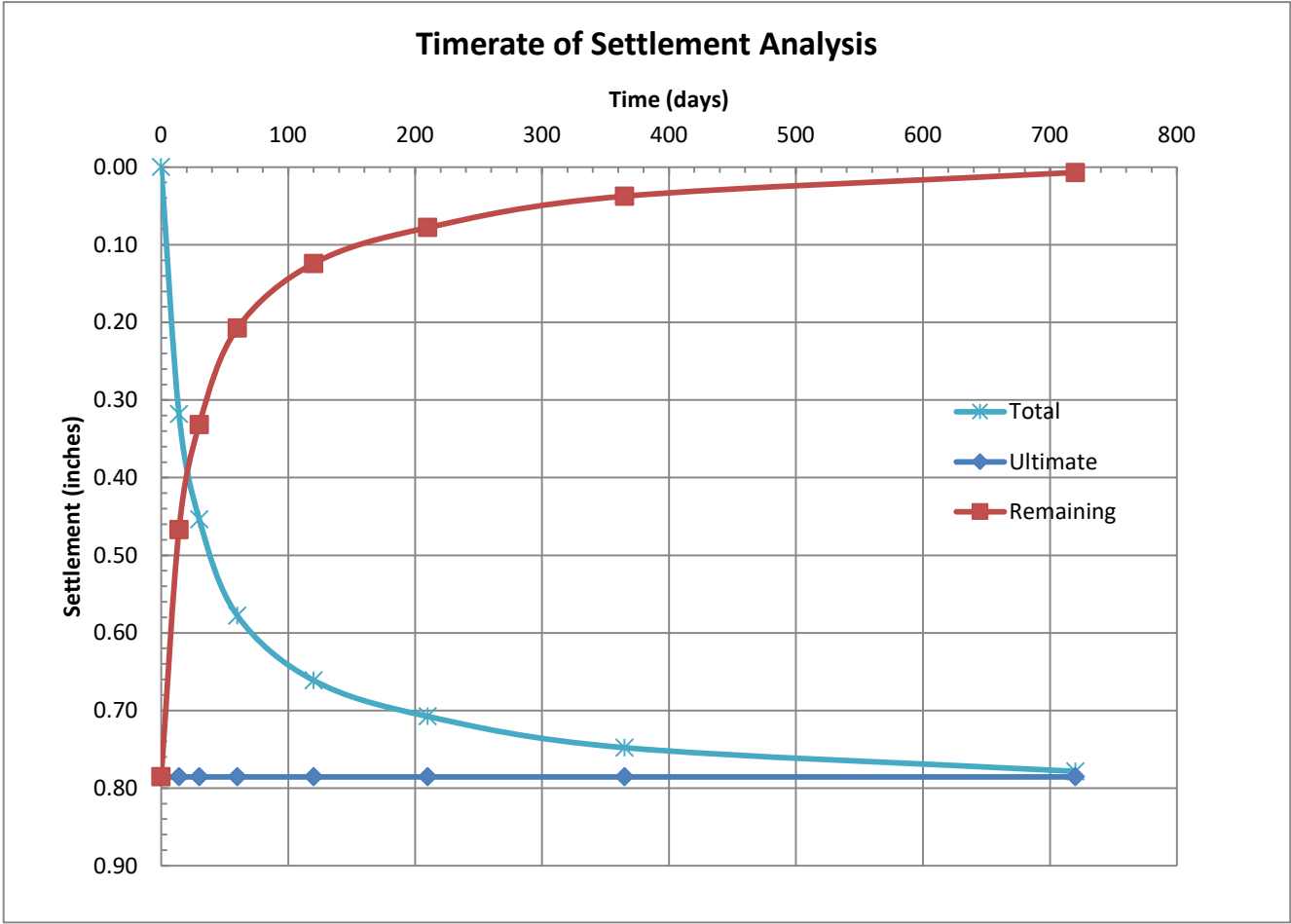
HDR Computation

Project:	HAM-126-19.50
Subject:	Sta. 7+16, 9.5 RT
Task:	Settlement

Computed:	DCM
Checked:	MM
Sheet:	2

Date:	12/29/2024
Date:	1/6/2025
of	2

Time	Total	Total	Ultimate	Remaining	%
days	Settlement (ft)	Settlement (inches)	Settlement (inches)	Settlement (inches)	Consolidation
0	0.00	0.00	0.79	0.79	0
14	0.03	0.32	0.79	0.47	41
30	0.04	0.45	0.79	0.33	58
60	0.05	0.58	0.79	0.21	74
120	0.06	0.66	0.79	0.12	84
210	0.06	0.71	0.79	0.08	90
365	0.06	0.75	0.79	0.04	95
720	0.06	0.78	0.79	0.01	99



Project: HAM-126-19.50

Subject: Sta. 7+16, 25 RT

Task: Settlement

Computed: DCM	Date:	12/29/2024
Checked: MM	Date:	1/6/2025
Revised DCM	Date:	6/16/2025

<u>Soil Type</u>	<u>Top</u>	<u>Bottom</u>	<u>Thickness</u>	<u>Layers</u>
L2 - VS Cohesive	818.5	814	4.5	1
L3 - Hard Cohesive	814	809.5	4.5	1
Bedrock	809.5			

- 1
- 2

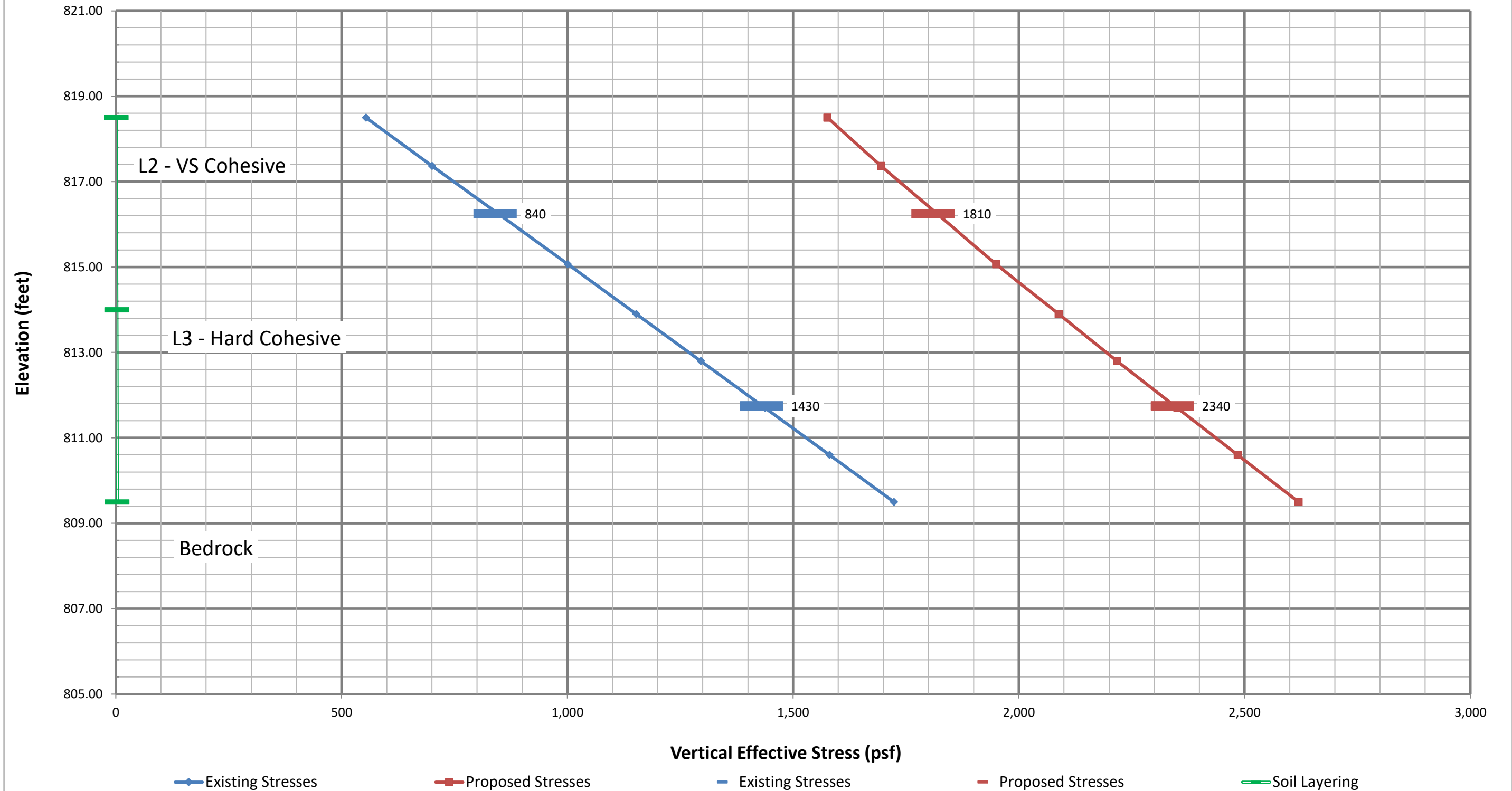
2 OK

[illegible][illegible][illegible]

HAM-126-19.50 - Pedestrian Bridge

Distribution of Vertical Effective Stress

Sta. 7+16 , 25 RT



Project: HAM-126-19.50

Subject: Sta. 7+16, 25 RT

Task: Settlement

	Approximate Consolidation	
Consolidation	50%	91%
Time (days)	14	180
Time (Months)	0.5	6

$$S = \sum \left[\frac{C_c}{1 + e_0} \cdot H \cdot \log \left(\frac{\sigma_f'}{\sigma_0'} \right) \right]$$
$$S = \sum \left[\frac{C_r}{1 + e_0} \cdot H \cdot \log \left(\frac{\sigma'_f}{\sigma'_0} \right) \right]$$
$$S = \sum \left[\frac{C_r}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma'_p}{\sigma_0} \right) + \frac{C_c}{1+e_0} \cdot H \cdot \log \left(\frac{\sigma'_f}{\sigma_p} \right) \right]$$

Soil Type	Top	Bottom	Thickness	Layers
L2 - VS Cohesive	818.5	814	4.5	1
L3 - Hard Cohesive	814	809.5	4.5	1
Bedrock	809.5	0	0	0

$$S_e = \sum_{i=1}^n \Delta H_i$$
$$\Delta H_i = H_c \frac{1}{C'} \log \left(\frac{\sigma'_o + \Delta \sigma_v}{\sigma'_o} \right)$$

S_e = total elastic (immediate) settlement
 n = number of soil layers within zone of stress influence of the footing
 ΔH_i = Elastic (Immediate) settlement of Layer i (ft)
 H_c = Initial height of layer i (ft)
 C' = bearing capacity index from Figure 10.6.2.4.2-1
 (AASHTO LRFD Bridge Design Manual - 2012)
 $1 = N(C_N)$
 $N1$ = SPT Blow count corrected for overburden pressure, σ'_{v1}
 $C_N = [0.77 \log_{10} (40/\sigma'_{v1})]$, where $C_N < 2.0$

[illegible]

TIME RATE OF SETTLEMENT

HDR Computation

Project: HAM-126-19.50

Subject: Sta. 7+16, 25 RT

Task: Settlement

Computed: DCM

Checked: MM

Sheet: 2

Date: 12/29/2024

Date: 1/6/2025

of 2

Time	Total	Total	Ultimate	Remaining	%
days	Settlement (ft)	Settlement (inches)	Settlement (inches)	Settlement (inches)	Consolidation
0	0.00	0.00	0.41	0.41	0
14	0.02	0.21	0.41	0.20	51
30	0.02	0.28	0.41	0.13	68
60	0.03	0.32	0.41	0.09	79
90	0.03	0.34	0.41	0.07	84
120	0.03	0.36	0.41	0.05	87
180	0.03	0.38	0.41	0.04	91
455	0.03	0.41	0.41	0.00	99

