Structural Geotechnical Report

IDOT PTB 204-001
Proposed Retaining Wall
Michigan City Road Bridge over I-94
Cook County, Illinois

Prepared for

Illinois Department of Transportation
Contract Number: D-91-158-22

Project Design Engineer Team
Delta Engineering Group, LLC

Geotechnical Consultant

GSG CONSULTANTS, INC.
Engineers. Scientists. Construction Managers
735 Remington Road, Schaumburg IL 60173
Tel: 630.994.2600, www.gsg-consultants.com

October 17, 2023

GSG CONSULTANTS, INC.

735 Remington Road
Schaumburg, IL 60173
Tel: 630.994.2600
www.gsg-consultants.com

October 17, 2023

Muhammad Arif, P.E, PTOE.
Senior Civil Engineer
Delta Engineering Group, LLC
111 West Jackson Blvd, Suite 910
Chicago, Illinois 60604

Structural Geotechnical Report
PTB 204-001
Proposed Retaining Wall
Michigan City Road Bridge over I-94
Cook County, IL

Dear Mr. Arif:

Attached is a copy of the Structural Geotechnical Report for the above referenced project. The report provides a description of the site investigation, site conditions, and foundation and construction recommendations. The site investigation for the proposed retaining wall included advancing four (4) soil borings to depths between 30 and 40 feet.

Should you have any questions or require additional information, please call us at 630-994-2600.

Sincerely,

A. Alyousef

Abdulaziz Alyousef, E.I.T.
Staff Engineer

Dawn Edgell.

Dawn Edgell, P.E.
Sr. Project Engineer

TABLE OF CONTENTS

1.0 INTRODUCTION 1
1.1 Existing Conditions 1
1.2 Proposed Retaining Wall Information 3
2.0 SITE SUBSURFACE CONDITIONS 4
2.1 Subsurface Exploration and Laboratory Testing 4
2.2 Laboratory Testing Program 5
2.3 Subsurface Soil Conditions 5
2.4 Groundwater Conditions 6
3.0 GEOTECHNICAL ANALYSES 8
3.1 Derivation of Soil Parameters for Design 8
3.2 Embankment 8
3.3 Seismic Parameters 8
4.0 GEOTECHNICAL WALL DESIGN RECOMMENDATIONS 10
4.1 Retaining Wall Type Recommendations 10
4.2 Retaining Wall Design Recommendations 11
4.3 Sliding and Overturning Stability 15
4.4 Wall and Embankment Settlement for CIP T Wall 15
4.5 Soldier Pile and Lagging 15
4.6 Global Slope Stability 16
4.7 Drainage Recommendations 18
5.0 CONSTRUCTION CONSIDERATIONS 19
5.1 Site Preparation 19
5.2 Existing Utilities and Structures 19
5.3 Site Excavation 20
5.4 Embankment Construction 20
5.5 Borrow Material and Compaction Requirements 21
5.6 Groundwater Management 21
5.7 Temporary Earth Retention Systems 22
6.0 LIMITATIONS 23

Exhibits

Exhibit 1 Project Location Map
Exhibit 2 Existing Site Conditions at Proposed Retaining Wall Location
Exhibit 3 Structural Fill Placement below CIP Wall Footing

Tables

Table 1 Preliminary Retaining Wall Summary
Table 2 Summary of Subsurface Exploration Borings
Table 3 Seismic Parameters
Table 4 LRFD Load Factors for Retaining Wall Analysis
Table 5 Equivalent Height of Soil for Vehicular Loading on Retaining Walls Parallel to Traffic
Table 6 Recommended Bearing Resistance for Retaining Wall
Table 7 Soldier Pile and CIP Wall Description
Table 8 Retaining Wall Global Slope Stability Analyses Results

Appendices

Appendix A Preliminary General Plan and Elevation
Appendix B Soil Boring Location Plan and Subsurface Profile
Appendix C Soil Boring Logs
Appendix D Laboratory Results
Appendix E Slope Stability Analyses Exhibits
Appendix F Soil Design Parameters

Structural Geotechnical Report
IDOT PTB 204-001
Proposed Retaining Wall
Michigan City Road over I-94
Cook County, Illinois

1.0 INTRODUCTION

GSG Consultants, Inc. (GSG) completed a geotechnical investigation for the proposed retaining wall as part of the Michigan City Road Bridge over I-94 project in the City of Dolton in Cook County, Illinois. The purpose of the investigation was to explore the subsurface conditions, to determine engineering properties of the subsurface soil, and develop design and construction recommendations for the proposed retaining wall. **Exhibit 1** shows the general project location.

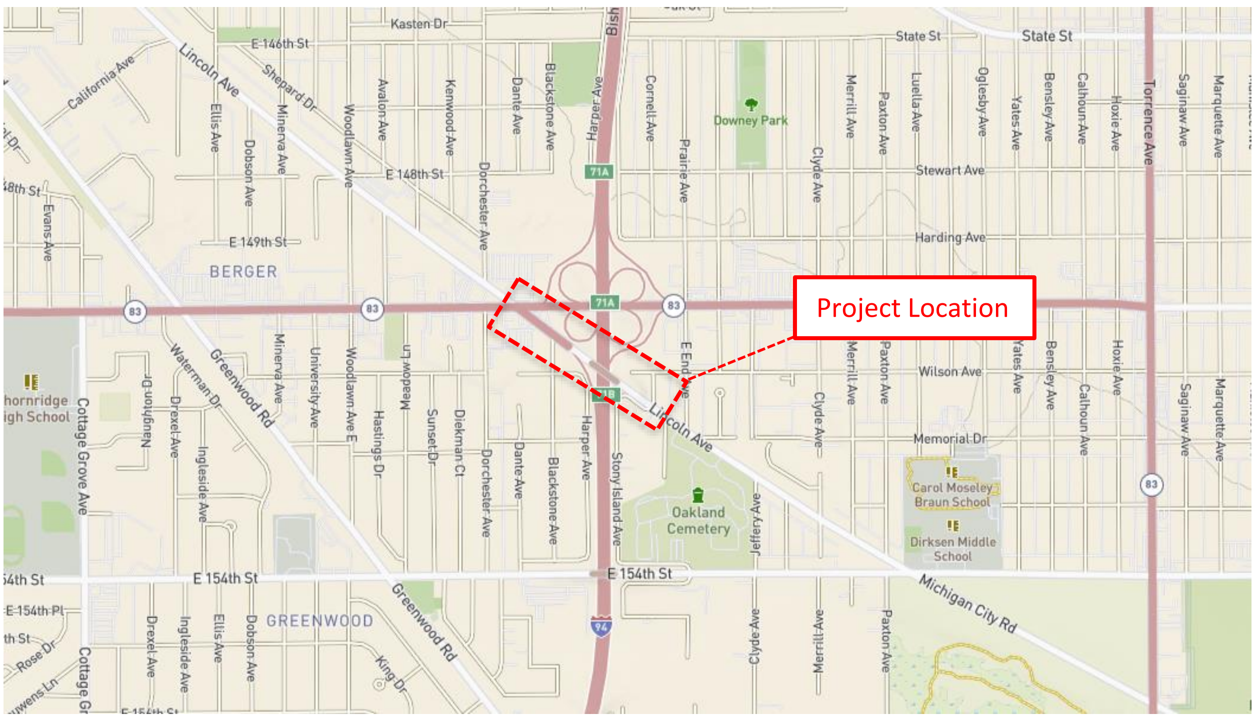


Exhibit 1 – Project Location Map
(Source: USGS Topographic Maps, usgs.gov)

1.1 Existing Conditions

The proposed improvements at this location will include construction of a new retaining wall on the embankment down slope to allow for adding new fill for widening the north side of Michigan City Road to provide shared use path. Michigan City Road is approximately 7 to 15 feet higher than the adjacent ramp. There will be fill sections to construct the wall within the existing embankment. **Exhibits 2a, 2b and 2c** show the existing conditions where the proposed retaining wall will be constructed.

Exhibit 2a – Existing Michigan City Road Westbound, Looking Northwest

Exhibit 2b – Existing Ramp, Looking Southeast

Exhibit 2c – Proposed Retaining Wall Location, Aerial

1.2 Proposed Retaining Wall Information

Based on preliminary design information provided by Delta Engineering, the proposed wall will be a fill section. The wall will support a 10-foot wide shared path that is proposed along Michigan City Road. According to the proposed Phase II plan drawings provided, the proposed retaining wall will be constructed approximately 46 feet north of the centerline of Michigan City Road within the existing embankment on the IDOT Right-of-Way. The proposed retaining wall will be approximately 210 feet in length, with a maximum retained height of approximately 12 feet. It is anticipated that the proposed structure will be either a Cast-in-Place (CIP) T wall or a soldier pile wall as shown in the Preliminary General Profile and Elevation (GP&E) plans provided by Delta (**Appendix A)**. **Table 1** presents a summary of the proposed structure.

Table 1 – Preliminary Retaining Wall Summary

Wall Name	Wall Stations*	Approximate Length (ft)	Maximum Anticipated Retained Wall Height (ft)
Retaining Wall	Sta. 394+50 to Sta. 396+60	210	12’-1/2”

* Based on Michigan City Road Stationing

2.0 SITE SUBSURFACE CONDITIONS

This section describes the subsurface exploration program and laboratory testing program completed as part of this project. The proposed locations and depths of the soil borings were selected in accordance with IDOT requirements and reviewed with Delta Engineering Group. The borings were completed in the field based on field conditions and accessibility.

2.1 Subsurface Exploration and Laboratory Testing

The site subsurface exploration for the proposed retaining wall structure was conducted on September 28, 2023. The investigation included advancing four (4) soil borings along the proposed alignment to depths between 30 and 40 feet. The locations of the soil borings were adjusted in the field as necessary based on utilities and access. Elevations and as-drilled locations for the borings were gathered by GSG's field crew using GPS surveying equipment and available google earth information. The approximate as-drilled locations of the soil borings are shown on the Soil Boring Location Plan & Subsurface Profiles **(Appendix B)**. **Table 2** presents a summary of the borings used for the proposed retaining wall analysis. Copies of the Soil Boring Logs are provided in **Appendix C**.

Table 2 – Summary of Subsurface Exploration Borings[1]

Boring ID	Station †	Offset (ft) †	Northing	Easting	Depth (ft)	Surface Elevation (ft)
RWB-01	394+52.69	15.2 LT	1805705.5	1190076.6	30.0	606.2
RWB-02	395+23.26	15.2 LT	1805665.1	1190128.2	30.0	606.7
RWB-03	395+90.61	21.0 LT	1805617.5	1190190.9	35.0	607.9
RWB-04	396+62.14	21.0 LT	1805579.9	1190241.9	40.0	609.3

† Based on proposed Michigan City Road Stationing

The soil borings were drilled using truck mounted CME-75 (hammer efficiency 79.8%) drill rig, equipped with 3¼-inch I.D. hollow stem augers and an automatic hammer. Soil sampling was performed according to AASHTO T 206, "Penetration Test and Split Barrel Sampling of Soils." Soil samples were obtained at 2.5-foot intervals to the boring termination depths. Water level measurements were made in each boring when evidence of free groundwater was detected on the drill rods or in the samples. The boreholes were also checked for free water immediately after auger removal, and before filling the open boreholes with soil cuttings and surface patching with asphalt where necessary to match the existing pavement.

GSG's field representative inspected, visually classified and logged the soil samples during the subsurface exploration activities and performed unconfined compressive strength tests on cohesive soil samples using a calibrated Rimac compression tester and a calibrated hand penetrometer in accordance with IDOT procedures and requirements. Representative soil samples were collected from each sample interval and were placed in jars and returned to the laboratory for further testing and evaluation.

2.2 Laboratory Testing Program

All samples were inspected in the laboratory to verify the field classifications. A laboratory testing program was undertaken to characterize and determine engineering properties of the subsurface soils encountered in the area. The following laboratory tests were performed on representative soil samples:

- Moisture Content – ASTM D2216 / AASHTO T-265
- Atterberg Limits – ASTM D4318 / AASHTO T-89 / AASHTO T-90

The laboratory tests were performed in accordance with test procedures outlined in the most current IDOT Geotechnical Manual, and per ASTM and AASHTO requirements. Based on the laboratory test results, the soils encountered were classified according to the AASHTO and the Illinois Division of Highways (IDH) classification systems. The results of the laboratory testing program are shown along with the field test results in the Soil Boring Logs **(Appendix C)** and in the Laboratory Results (**Appendix D)**.

2.3 Subsurface Soil Conditions

This section provides a brief description of the soils encountered in the borings performed in the vicinity of the proposed retaining wall. Variations in the general subsurface soil profile were noted during the drilling activities. Detailed descriptions of the subsurface soils are provided in the soil boring logs and are shown graphically in the Boring Location Plan & Subsurface Profiles. The soil boring logs provide specific conditions encountered at each boring location and include soil descriptions, stratifications, penetration resistance, elevations, location of the samples, and laboratory test data. Unless otherwise noted, soil descriptions indicated on boring logs are visual identifications. The stratifications shown on the boring logs represent the conditions only at the actual boring locations and represent the approximate boundary between subsurface materials; however, the actual transition may be gradual.

The surface elevations of the borings ranged between 606.2 and 609.3 feet. The borings initially encountered 10 inches of concrete pavement followed by 5 inches of aggregate subbase. Beneath the pavement section, dark brown and brown sand fill materials were encountered to depths of 5 to 10 feet. Boring RWB-03 noted sand fill with clay tile fragments between 6 to 7.5 feet.

Beneath the fill materials, the borings encountered loose to dense light brown sand to depths ranging from 12 to 16 feet, followed by loose to medium dense gray sand to depths ranging between 17 to 18.5 feet. Below the native sand, loose to dense gray silty loam was encountered to depths ranging between 21 to 23.5 feet below grade. Boring RWB-03 noted medium stiff gray silty clay at a depth of 22.5 to 30 feet below grade. The borings then encountered stiff to very stiff gray silty clay to the boring termination depths. Boring RWB-01 encountered cobbles at 17 feet below grade.

Overall, the native light brown sand had SPT blow count (N) values ranging from 5 to 33 blows per foot with an average value of 19 blows per foot (bpf). The native gray sand had SPT N values ranging from 10 to 29 bpf with an average value of 21 bpf. The native gray silty loam had SPT N values ranging from 9 to 30 bpf with an average value of 17 bpf. The medium stiff gray silty clay at boring RWB-03 had unconfined compressive strengths between 0.8 tsf and 1.0 tsf with an average strength of 0.86 tsf. The stiff to very stiff gray silty clay had unconfined compressive strength between 1.04 tsf and 3.1 tsf with an average strength of 1.9 tsf.

2.4 Groundwater Conditions

Water levels were checked in each boring to determine the general groundwater conditions present at the site and were measured while drilling and after each boring was completed. Water was observed at depths between 11.0 to 13.5 feet (EL. of 595.2 and 595.8 feet) in all borings withing the sand layer. The borings were not left open after leaving the site due to safety concerns.

Based on the observed water levels and soil color change from brown to gray, it is anticipated that the long-term groundwater level may be at an approximate depth between 12 to 16 feet (EL. of 591.9 to 594.2 feet). Perched water may also be present within the fill materials and confined granular layers. Water level readings were made in the boreholes at times and under conditions shown on the boring logs and stated in the text of this report. However, it should be noted that fluctuations in groundwater level may occur due to variations in the rainfall, other climatic conditions, or other factors not evident at the time measurements were made and reported herein.

3.0 GEOTECHNICAL ANALYSES

This section provides GSG's geotechnical analysis for the design of the proposed retaining wall and embankment based on the results of the field exploration, laboratory testing, and geotechnical analysis. Subsurface conditions between borings may vary from those encountered at the boring locations. If structure locations, loadings, or elevations are changed, we request that GSG be contacted so that we may re-evaluate our recommendations.

3.1 Derivation of Soil Parameters for Design

Soil parameters for the design of the wall were developed based on the most recent design information and the soil borings information available. Soil parameter tables developed for the proposed wall are presented in **Appendix F**.

3.2 Embankment

Based on the provided plans (**Appendix A**), the existing embankment will be widened at the roadway level by approximately 2 to 17 feet. New engineered fill will be placed on top of the existing embankment slope and retained by the proposed retaining wall. Based on the cross-section drawings, the height of the existing embankment ranges is between 5 to 14 feet. The height of the new fill behind the proposed retaining wall ranges between 2 and 5 feet.

Existing slopes steeper than 3H:1V or higher than 15 feet (STA 395+30 to 396+00) should be stepped and benched to provide a level surface for the placement and compaction of the new fill materials. Benching will provide level surfaces for compaction and reduce the development of inclined planes of potential weakness between the existing soil and the fill material. The embankment should be constructed as early as possible in the project construction period in order to allow the embankments settle under its own weight prior to pavement construction.

3.3 Seismic Parameters

The seismic hazard for the site was analyzed per the IDOT Geotechnical Manual, IDOT Bridge Design Manual, and AASHTO LRFD Bridge Design Specifications. The Seismic Soil Site Class was determined per the requirements of All Geotechnical Manual Users (AGMU) Memo 9.1, Design Guide for Seismic Site Class Determination, and the "Seismic Site Class Determination" Excel spreadsheet provided by IDOT. A global Site Class Definition was determined for this project, and was found to be Soil Site Class D. The Seismic Performance Zone (SPZ) was determined using Figure 2.3.10-2 in the IDOT Bridge Manual and was found to be Seismic Performance Zone 1.

The AASHTO Seismic Design Parameters program was used to determine the peak ground acceleration coefficient (PGA), and the short (S_{DS}) and long (S_{D1}) period design spectral acceleration coefficients for each of the proposed structures. For this section of the project, the S_{DS} and the S_{D1} were determined using 2020 AASHTO Guide Specifications as shown in **Table 3**. Given the site location and materials encountered, the potential for liquefaction is minimal.

Table 3 – Seismic Parameters

Building Code Reference	PGA	S_{DS}	S_{D1}
2020 AASHTO Guide for LRFD Seismic Bridge Design	0.043g	0.151g	0.09g

4.0 GEOTECHNICAL WALL DESIGN RECOMMENDATIONS

This section provides retaining wall design parameters including recommendations on foundation type, bearing capacity, settlement, and lateral earth pressures. The foundations for the proposed retaining walls must provide sufficient support to resist the dead and live loads, as well as seismic loading.

4.1 Retaining Wall Type Recommendations

It is anticipated that the proposed retaining wall will be constructed predominantly within a fill section of the existing embankment. There are various types of retaining walls that could be utilized for retaining earthen pressures in fill areas. This section discusses several earth retaining structures that could be used for the proposed project. Typical wall types are described in the section below.

4.1.1 Soldier Pile and Lagging Walls

Soldier pile and lagging walls can be used to retain new fill with moderate retained heights and where the existing ground surface needs to be maintained during construction or when a near vertical excavation is needed. The wall may be constructed with driven steel piles or steel piles placed in drilled holes and backfilled with concrete.

4.1.2 CIP Concrete Cantilever Walls

CIP concrete cantilever retaining walls are constructed with a footing that extends laterally both in front of and behind the wall. They can be designed to resist horizontal loading with or without tie-backs by changing the geometry of the foundation. This type of wall typically requires that the area behind the wall be excavated to facilitate construction or are constructed where new fill embankments are necessary.

The advantages of a CIP wall include that it is a conventional system with well-established design procedures and performance characteristics; it is durable; and it has the ability to easily be formed, textured, or colored to meet aesthetic requirements. Disadvantages include a relatively long construction period due to undercutting, excavation, form work, steel placement, and curing of the concrete. This wall system is also sensitive to total and differential settlements.

4.1.3 Recommended Wall Type

CIP T wall or solider pile and lagging walls could be used for this project. The T-wall will require installation of a temporary earth retention system within the existing embankment.

GSG evaluated the global and external stability and settlement to determine the suitability of each of the recommended retaining wall types for this project. The wall section should be analyzed to determine adequate factors of safety relative to overturning failure. The contractor is responsible for providing a detailed internal stability design for the wall. The wall should be designed, and constructed, in accordance with the proprietary contractor's construction manual. The final wall design should be submitted to the structural design team for review prior to commencing construction of the wall.

4.2 Retaining Wall Design Recommendations

The engineering analyses performed for evaluation of the retaining wall options followed the current AASHTO Load and Resistance Factor Design (LRFD) Methodology as required by IDOT. LRFD methodology incorporates the use of load factors and resistance factors to account for uncertainty in applied loads and load resistance of structure elements separately. The AASHTO LRFD Bridge Design Specifications outline load factors and combinations for various strength, extreme event, service, and fatigue limit states. Section 11, which outlines geotechnical criteria for retaining walls, of the AASHTO Specifications requires the evaluation of bearing resistance failure, lateral sliding, and overturning at the strength limit state and excessive vertical displacement, excessive lateral displacement, and overall stability at the service limit state. The selected wall should be evaluated with respect to the collision load. **Table 4** outlines the load factors used in evaluation of the retaining wall in accordance with AASHTO Specification Tables 3.4.1-1 and 3.4.1-2.

Table 4 - LRFD Load Factors for Retaining Wall Analyses

	Type of Load	Sliding and Eccentricity Strength	Bearing Resistance Strength I	Sliding and Eccentricity Extreme II	Bearing Resistance Extreme II	Settlement Service I
Load Factors for Vertical Loads	Dead Load of Structural Components (DC)	0.90	1.25	1.00	1.00	1.00
	Vertical Earth Pressure Load (EV)	1.00	1.35	1.00	1.00	1.00
	Earth Surcharge Load (ES)		1.50			
	Live Load Surcharge (LS)		1.75		0.50	1.00
Load Factors for Horizontal Loads	Horizontal Earth Pressure Load (EH) Active At-Rest AEP for anchored walls	1.50	 1.50 1.35 1.35	1.00	1.00	1.00
	Earth Surcharge (ES)	1.50	1.50			
	Live Load Surcharge (LS)	1.75	1.75	0.50	0.50	1.00
Load Factor for Vehicular Collision				1.00	1.00	

4.2.1 Lateral Earth Pressures and Loading

The wall should be designed to withstand earth and live lateral earth pressures. The lateral earth pressures on retaining walls depend on the type of wall (i.e. restrained or unrestrained), the type of backfill and the method of placement against the wall, and the magnitude of surcharge weight on the ground surface adjacent to the wall. The active earth pressure coefficient (Ka), and the passive earth pressure coefficient (Kp) were determined in accordance with AASHTO Section 3.11.5.3 and 3.11.5.4. The soil design properties, including the recommended lateral soil modulus and soil strain parameters that can be used for laterally loaded pile analysis via the p-y curve method based on the encountered subsurface conditions, are provided in **Appendix F** for the retaining wall for the anticipated soil types at the site.

Traffic and other surcharge loads should be included in the retaining wall design as applicable. The traffic on Michigan City Road is approximately 12 feet behind the back face of the wall, which is more than one-half the wall height (12 feet), therefore traffic load should not be included in the design. A pedestrian load of 75 psf should be applied on top of the wall in accordance with AASHTO 3.6.1.6.

The retaining wall design should include a drainage system to allow movement of any water behind the wall, and not allowing hydrostatic (seepage) pressures to develop in the active soil wedge behind the wall. This could be accomplished by placing a Geocomposite Wall Drain over the entire length of the back face of the wall connected to a perforated drainpipe and backfilling a minimum of 2 feet of free draining materials, Porous Granular Embankment, as measured laterally from the back of the wall. The backfill should be placed in accordance with the IDOT SSRBC.

Heavy compaction equipment should not be allowed closer than five (5) feet to the retaining wall to prevent inducing high lateral earth pressures and causing wall yielding and/or other damage. The passive lateral earth pressure coefficient (Kp) from the upper 3.5 feet of level backfill at the toe of the wall should be neglected, unless the soil is confined or protected by a concrete slab or well drained pavement. The passive lateral earth pressure coefficient from the upper 3.5 feet of soil for a descending slope at the wall toe should also be neglected, regardless of any surface protection.

4.2.2 Bearing Resistance for CIP Wall

Bearing resistance for the retaining wall founded on spread footings shall be evaluated at the strength limit state using load factors (See **Table 4**), and factored bearing resistance. The bearing resistance factor, ϕ_b, for a gravity wall is 0.55 per AASHTO Table 11.5.7-1. The bearing resistance shall be checked for the extreme limit state with a resistance factor of 1.0.

The minimum depth of the wall foundation should be 3.5 feet below the final exterior grade to alleviate the effects of frost. The subgrade soils encountered at the bearing elevation should be cleared of any unsuitable material, such as topsoil or fill. The final exterior grade at the proposed face of the wall is anticipated to be at Ele. 602 to 605.7 feet based on the preliminary plan (**Appendix A**) for the T wall. The proposed bottom elevation of the wall varied between 598 to 599.3 feet. At this elevation, loose to medium dense sand with SPT N values between 10 to 17 and moisture between 15 to 25% was encountered. It is recommended to remove a minimum of 2 feet of loose sand and replace it with structural granular fill to the designed footing elevation. **Table 6** summarizes the available resistance and anticipated settlement if the wall designed using the above recommendations.

Table 6 – Recommended Bearing Resistance for CIP Wall

Boring IDs	Proposed Bottom of Footing Elevation* (feet)	Nominal Resistance (ksf)**	Factored Bearing Resistance (ksf)**	Bearing Resistance for 1-inch Settlement** Service Limit (ksf)	Anticipated Bearing Soil
RWB-01 thru RWB-04	598 to 599.3	12.2	6.7	5.0	Granular Structural Fill

*Based on preliminary GP&E (**Appendix A**)

**Assumed properties of bearing soil layer: friction angle = 28°, unit weight = 120 pcf, resistance factor = 0.55

***This settlement does not include the immediate settlement, which is expected to be approximately 0.7 inches and completed during the construction.

4.2.3 Subgrade Undercut Areas for CIP T Wall

As discussed in section 4.2.2, the loose sand under the proposed footing should be removed and replaced with granular structural fill in accordance with IDOT standard construction requirements. The lateral limit of the structural fill should extend a minimum of 1 foot beyond the edge of the footing, then an additional 1 foot laterally for every 2 feet of structural fill depth as depicted in **Exhibit 3**. The granular structural fill should be placed and compacted to a minimum of 95% of the maximum dry density, as determined by AASHTO T-180: Standard Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures (ASTM D1557) in accordance with IDOT standard construction requirements.

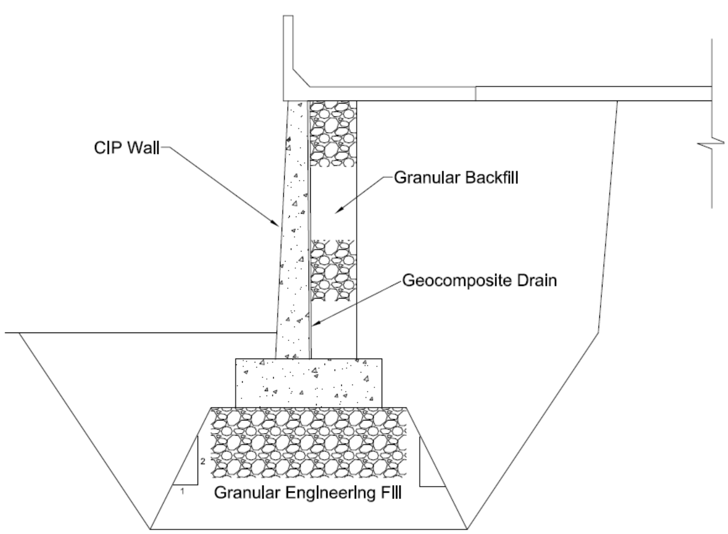


Exhibit 3 - Structural Fill Placement below CIP Wall Footing

4.3 Sliding and Overturning Stability

The wall base width should be sufficient to resist sliding. The frictional resistance shall include the friction between granular backfill for the wall and supportive granular soils, and the friction between the wall foundation and bearing soils.

The factored resistance against sliding should be calculated using equation 10.6.3.4-1 in the AASHTO LRFD manual. A sliding resistance factor, ϕ, of 1.0 (Table 11.5.7-1) shall be applied to the nominal sliding resistance of soil-on-soil beneath the retaining wall. A maximum frictional coefficient of 0.53 (tan 28 degrees) could be used for determining the sliding resistance for the soil-to-soil interfaces. The width of the retaining wall must be wide enough to resist overturning forces. The location of the resultant of the forces shall be within the middle two-thirds of the base width.

4.4 Wall and Embankment Settlement for CIP T Wall

Settlement of the CIP wall depends on the foundation size and bearing resistance, as well as the strength and compressibility characteristics of the underlying bearing soil. Assuming the foundation subgrade has been prepared as recommended above and the service bearing resistances as noted in **Table 6** are used, the settlement of the CIP wall will be on the order of 1 inch. Differential settlement between two points of 100 feet apart along the length of the wall will be ½ inch or less.

4.5 Soldier Pile and Lagging

Soldier pile walls are generally constructed at 8 to 10-foot centers along the retaining wall alignment into the bearing stratum. The soldier piles could either be driven or drilled. Driving piles is normally less expensive but the designs are limited to H-pile and small W-sections. Drilled soldier piles can utilize larger W-sections, built up plate sections or multiple W-sections. For drilled piles, the pile will be placed into the hole and centered, and the annular space around each pile section will be filled with flowable grout. The lagging and piles should be designed based on structural analysis.

Resistance to lateral movement or overturning of the soldier pile is furnished by passive resistance of the soil below the depth of excavation. The design should include a structural evaluation of the pile section to meet applied shear and moment, and an evaluation of overturning to determine embedment depth and other design requirements. The walls shall be designed to withstand earth and live lateral earth pressures. The lateral earth pressures on retaining walls depend on the type of wall (i.e. restrained or unrestrained), the type of backfill and the method of placement against the wall, and the magnitude of surcharge weight on the ground surface adjacent to the wall. Soldier pile walls are considered flexible and such the earth loads may be calculated using active earth pressure for load above the design grade, and both active and passive earth pressures below the design grade. The active earth pressure coefficient (Ka), and the passive earth pressure coefficient (Kp) are presented in **Appendix F**.

The simplified earth pressure distributions shown in Section 3.11.5.6 of the AASHTO Standard Specifications for Highway Bridges could be used for the wall design. **Appendix F** also provides recommended lateral soil modulus and soil strain parameters that can be used for laterally loaded pile analysis via the p-y curve method based on the encountered subsurface conditions. The passive resistance in front of the wall should be ignored for the upper 3.5 feet due to excavation activities and frost-heave conditions. Construction equipment surcharge loads should be added to the lateral earth pressure.

To limit wall deflections and provide additional resistance, the soldier pile and lagging retention system could be restrained with tie-back anchors. The soldier pile and lagging retention system restrained with tie-backs will be subjected to apparent earth pressure distributions as described in section 3.11.5.7 of the AASHTO Standard Specifications for Highway Bridges. For tall retaining walls, the apparent earth pressure will result in greater lateral forces and moments compared to the cantilever design.

4.6 Global Slope Stability

Based on the preliminary information provided by Delta Engineering Group, the retaining wall should be designed for external stability of the wall system. The geometries in **Table 7a and 7b** for Station 396+60 with the highest wall and Station 395+75 with largest exposed heights were used to evaluate the global slope stability of the proposed walls.

Table 7a – Cast-In-Place (CIP) Wall Description
*Based on preliminary drawings provided

Location	396+60	395+75
Maximum total retained height of retaining wall (ft)	12.54	10.875
CIP retaining wall footing width – minimum (ft)	8.75	8.75
CIP retaining wall footing depth – minimum (ft)	3.5	3.5

Table 7b – Soldier Pile Wall Description
Based on preliminary drawings provided

Location	396+60	395+75
Maximum total exposed height of retaining wall	4.9	7.4
Minimum embedment length for frost protection*	3.5	3.5
Pile tip elevation – estimated	598.3	598.3

*Additional embedment may be required for lateral pressures and structural design of the wall system

The actual wall height and width should be based on structural analysis performed by a Licensed Structural Engineer in the State of Illinois.

Slide2 is a comprehensive slope stability analysis software used to evaluate the proposed wall for the project based on the limit equilibrium method. The proposed wall was analyzed based on the preliminary grading and the soils encountered while drilling. Circular failure analyses were evaluated using the simplified Bishops analyses methods for the proposed wall geometries. Based on the proposed geometry and the soil borings, global stability analyses were performed.

4.6.1 Global Slope Stability Results

Circular failure analyses were evaluated for both a short term (undrained) and long term (drained) conditions based on the proposed geometries (**Tables 7**) for the proposed CIP Wall and soldier pile wall, respectively. The results of the analyses are shown in **Table 8**.

Table 8 – Retaining Wall Global Slope Stability Analyses Results

Analysis Exhibit	Location	Wall Type	Analysis Type	Factor of Safety	Minimum Factor of Safety
Exhibit a	Station 396+60	CIP Wall	Circular – Short Term	2.6	1.5
Exhibit b			Circular – Long Term	2.6	1.5
Exhibit c	Station 395+75		Circular – Short Term	2.1	1.5
Exhibit d			Circular – Long Term	2.0	1.5
Exhibit e	Station 396+60	Soldier Pile	Circular – Short Term	2.4	1.5
Exhibit f			Circular – Long Term	2.4	1.5
Exhibit g	Station 395+75		Circular – Short Term	1.9	1.5
Exhibit h			Circular – Long Term	1.6	1.5

Based on the analyses performed, the proposed retaining wall preliminary design meets the minimum factor of safety of 1.5 for walls in fill slopes per IDOT. Copies of the slope stability analyses are included in the Slope Stability Analyses Exhibits (**Appendix E**).

4.7 Drainage Recommendations

The wall design should include a drainage system to prevent the buildup of hydrostatic forces behind the wall. This could be accomplished with the installation of drainage blankets, geocomposite drainage panels, or gravel drains behind the facing of the wall with outlet pipes below the facing to collect and remove surface water away from the face of the wall. If weep holes are to be used, it is recommended that a geocomposite wall drain be placed over the interlocks and area of the weep holes. If drainage is not provided, hydrostatic pressure should be included in the wall design and the horizontal earth pressure should be determined in accordance with AASHTO Article 3.11.3.

5.0 CONSTRUCTION CONSIDERATIONS

All work performed for the proposed project should conform to the requirements in the IDOT Standard Specifications for Road and Bridge Construction (SSRBC) (2022). Any deviation from the requirements in the manuals above should be approved by the design engineer.

5.1 Site Preparation

All trees, pavements, vegetation, landscaping, and surface topsoil should be cleared and removed from the vicinity of the proposed foundations. Where possible, the engineer may require proof-rolling of the subgrade with a 35-ton loaded truck or other pneumatic-tired vehicle of similar size and weight. The purpose of the proof-rolling is to locate soft, weak, or excessively wet soils present at the time of construction. Proof-rolling should be performed during a time of good weather and not while the site is wet, frozen, or severely desiccated. Any unsuitable materials observed during the evaluation and proof-rolling operations should be undercut and replaced with compacted structural fill and/or stabilized in-place. The possible need for, and extent of, undercutting and/or in-place stabilization required can best be determined by the geotechnical engineer at the time of construction. Once the site has been properly prepared, at grade construction may proceed.

Foundation aggregate fill should not be placed upon wet or frozen subgrade soils. If the subgrade or structural fill becomes frozen, desiccated, wet, disturbed, softened, or loose, the affected materials should be scarified, dried and moisture conditioned, and compacted to the full depth of the affected area or the soils should be removed. Rainfall and runoff can soften soils and affect the load bearing capacity of the soils. All water entering foundation excavation should be removed prior to placement backfill materials above the wall bottom.

5.2 Existing Utilities and Structures

Before proceeding with construction, all existing underground utility lines or structures that will interfere with construction should be completely relocated from the proposed construction areas. Where possible, existing utility lines that are to be abandoned in place should be removed and/or plugged with a minimum of 2 feet of cement grout. All excavations resulting from underground utilities or structure removal activities should be cleaned of loose and disturbed materials, including all previously placed backfill, and backfilled with suitable fill materials in accordance with the requirements of this section. During the clearing and stripping operations, positive surface drainage should be maintained to prevent the accumulation of water.

5.3 Site Excavation

Site excavations are expected to encounter various types of soils as described in the Subsurface Exploration section of this report. The contractor will be responsible for providing a safe excavation during the construction activities of the project. All excavations should be conducted in accordance with applicable federal, state, and local safety regulations, including, but not limited to the Occupational Safety and Health Administration (OSHA) excavation safety standards. Excavation stability and soil pressures on temporary shoring are dependent on soil conditions, depth of excavations, installation procedures, and the magnitude of any surcharge loads on the ground surface adjacent to the excavation. Excavation near existing structures and underground utilities should be performed with extreme care to avoid undermining existing structures. Excavations should not extend below the level of adjacent existing foundations or utilities unless underpinning or other support is installed. It is the responsibility of the contractor for field determinations of applicable conditions and providing adequate shoring (if needed) for all excavation activities.

5.4 Embankment Construction

The existing embankment will be widened at the top of the Michigan City Road and the added embankment should be constructed in accordance with Section 205 Embankment of IDOT SSRBC. The new fill should be benched into the side slopes of the existing embankment to provide interlocking between the old and new fill. GSG recommends benching the slopes according to Article 205.03 and placement according to Article 205.04 of IDOT SSRBC. Failure of the widened embankment may occur due to inadequate benching into the existing embankment and no proper drainage control during construction. GSG recommends including typical benching detail developed by IDOT District One or similar detail in the contract plan.

GSG recommends removing existing vegetation from the existing embankment without destabilizing the slopes before placement of new fill. Maintenance of the slope during the construction will be required for localized areas where erosion-prone soils (silt and sand) are encountered. These soils will develop minor sloughing; however, major sloughing may occur if these soils are saturated with perched groundwater. These conditions should be observed during construction and corrective measures should be taken. Heavy construction equipment and material should not be placed near the top of the existing slope.

5.5 Borrow Material and Compaction Requirements

If borrow material is to be used for onsite construction, it should conform to Section 204 "Borrow and Furnish Excavations" of the IDOT Construction Manual (2021) and the District One Embankment I Special Provision. Imported or on-site fill materials should be evaluated using Table 8.4-1 of the IDOT Geotechnical Manual, Requirements of Borrow Soils for the top 24 inch, and Section 204, "Borrow and Furnish Excavations" of the IDOT SSRBC.

The fill material should be free of organic matter and debris and should be placed and compacted in accordance with Section 205, Embankment, of the IDOT SSRBC (2021) and the District One Embankment I Special Provision. Earth-moving operations should be avoided during excessively cold or wet weather to avoid freezing of softening subgrade soils. Fill should be placed in lifts and compacted according to Section 205, Embankment (IDOT, 2016) and the District One Embankment I Special Provision.

5.6 Groundwater Management

Long term groundwater may be at elevations between 593.3 and 594.2 feet. However, perched water is expected to be encountered within the existing fill materials. If rainwater run-off or groundwater is accumulated at the base of excavations, the contractor should remove accumulated water using conventional sump pit and pump procedures and maintain a dry and stable excavation. The location of the sump should be determined by the contractor based on field conditions. During earthmoving activities at the site, grading should be performed to ensure that drainage is maintained throughout the construction period. Water should not be allowed to accumulate in the foundation area either during or after construction. Undercut and excavated areas should be sloped toward one corner to facilitate the removal of any collected rainwater or surface run-off. Grades should be sloped away from the excavations to minimize runoff from entering.

If water seepage occurs during excavations or where wet conditions are encountered such that the water cannot be removed with conventional sumping, we recommend placing open-grade stone similar to IDOT CA-7 to stabilize the bottom of the excavation below the water table. The CA-7 stone should be placed 12 inches above the water table, in 12-inch lifts, and should be compacted with the use of a heavy smooth drum roller or heavy vibratory plate compactor until stable. The remaining portion of the excavation beneath the footings should be backfilled using approved structural fill.

5.7 Temporary Earth Retention Systems

Temporary soil retention systems (TSRS) will be required for the construction of either the CIP T Wall or soldier pile wall, as shown on the preliminary GPE plans. Based on the soil profile, a cantilevered sheet pile system could be used. The sheet pile retaining system should be designed in accordance with the IDOT Bridge Design Manual, Section 3.13.1, Temporary Sheet Piling Design, Temporary Soil Retention Systems. The design of the TSRS is the responsibility of the contractor.

The IDOT Temporary Sheet Piling Design procedures include limitations if the required embedment depths fall below soil layers with a Qu value larger than 4.5 tsf or N-values larger than 45 blows or rock, because the sheet piling may not penetrate these layers. Refer to the soil boring logs for the elevations to the hard stratum. If adequate retained heights cannot be obtained using the IDOT Temporary Sheet Piling Design Guide, then a Temporary Soil Retention System shall be designed by the Contractor. The Temporary Soil Retention Systems should include surcharge loads from the excavated materials, construction equipment, and truck traffic as necessary. The retention system should extend to a sufficient depth below the excavation bottom to provide the required lateral passive resistance if the active case is used for the design. Embedment depths should be determined based on the principles of force and moment equilibrium.

The retention system shall be designed by an Illinois-licensed structural engineer in accordance with the IDOT Bridge Design Manual. The design of the temporary soil retention system (TSRS) is the responsibility of the contractor. The contractor should submit the TSRS plans to the structural design team for review prior to commencing construction of the TSRS.

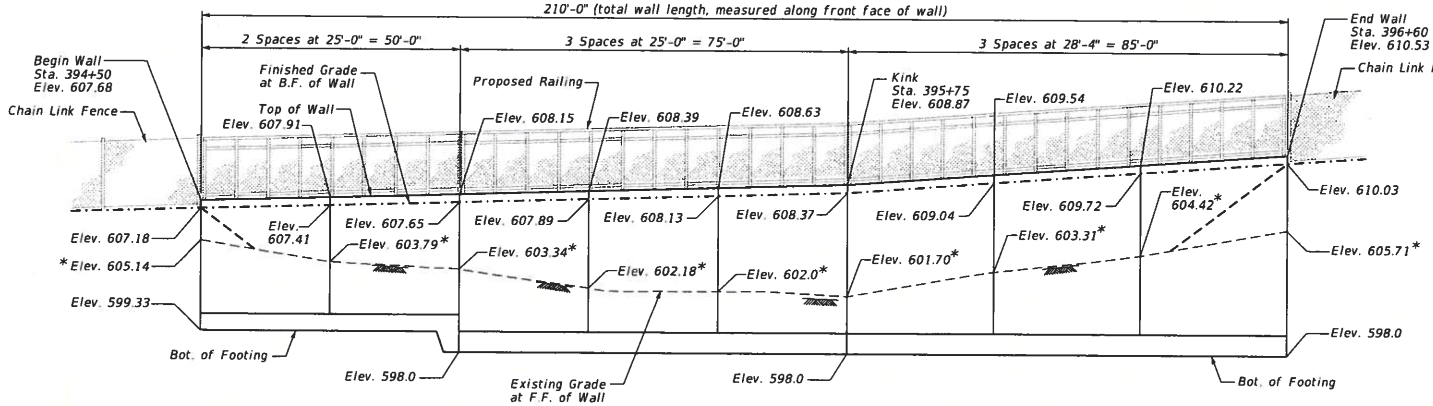
6.0 LIMITATIONS

This report has been prepared for the exclusive use of the Illinois Department of Transportation (IDOT) and its Design Section Engineer consultant. The recommendations provided in the report are specific to the project described herein and are based on the information obtained at the soil boring locations within the proposed retaining wall area. The analyses have been performed and the recommendations provided in this report are based on subsurface conditions determined at the location of the borings. This report may not reflect all variations that may occur between boring locations or at some other time, the nature and extent of which may not become evident until during the time of construction. If variations in subsurface conditions become evident after submission of this report, it will be necessary to evaluate their nature and review the recommendations presented herein.

Appendix A

Preliminary GPE

Bench Mark: Chiseled square cut in Northeast corner of wingwall at Northwest corner of Michigan City Road deck Elev. 613.98.
Existing Structure: None

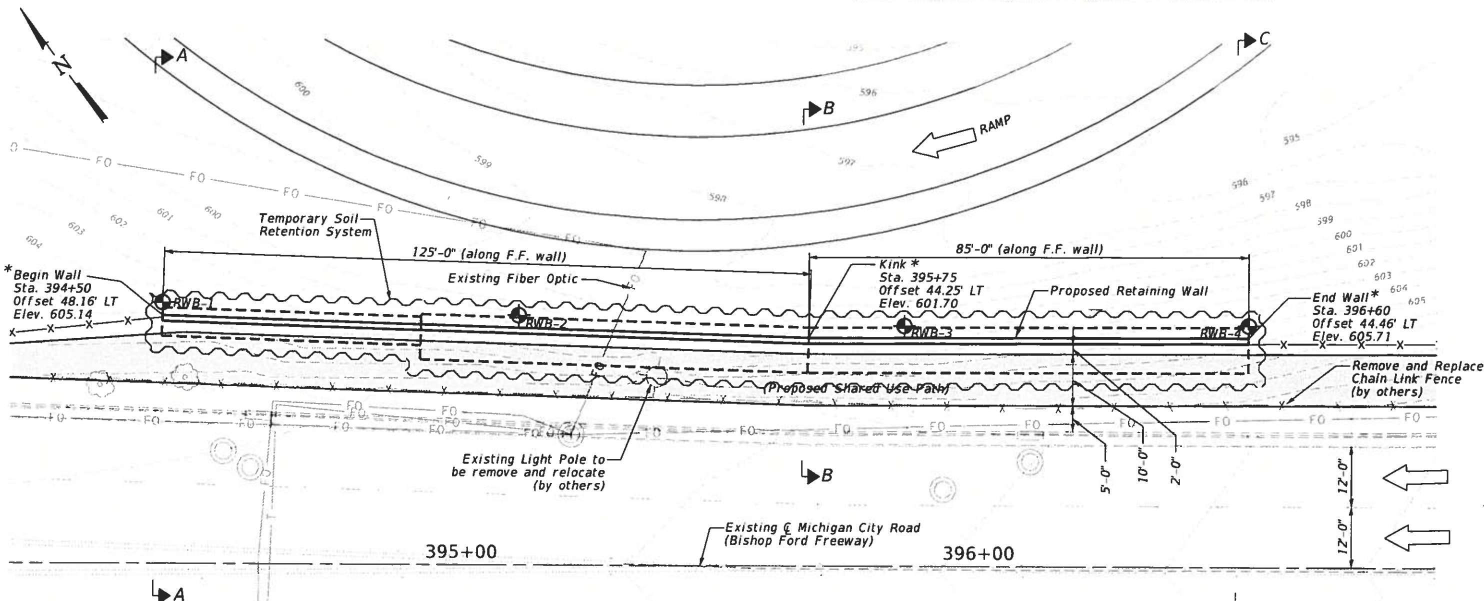


ELEVATION PROFILE
(Looking @ B.F. Wall)

Surveyor verify the (*) elevation at the Front Face of Wall for finish grading.

Elevations shown on the exhibit are approximate for Wall type study purpose only. They will be finalized after survey verification.

The Retaining Wall alignment and elevation are developed based on Phase I proposed Michigan City Road profile grade and existing embankment contours. They shall be checked by roadway design group for consistence with the roadway final geometry before allowed to be use for final wall TSL.



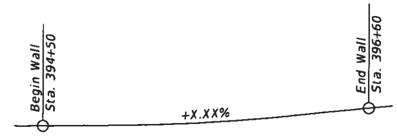
PLAN

DESIGN SPECIFICATIONS
2020 AASHTO LRFD Bridge Design Specifications, 9th Edition with 2015 Interims

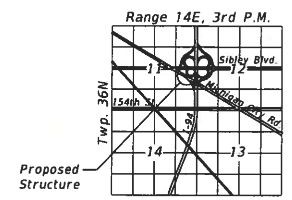
DESIGN STRESSES
FIELD UNITS

f'c = 3,500 psi
fy = 60,000 psi (Reinforcement)

HIGHWAY CLASSIFICATION
Michigan City Road
Functional Class: Other Principal Arterial
ADT: 9,300 (2014); 9,579 (2032)
ADTT: 279 (2014); 287 (2032)
DHV: 930 (2014)
Design Speed: 35 m.p.h.
Posted Speed: 35 m.p.h.
Two-Way Traffic
Directional Distribution: 50:50



PROPOSED FROFILE GRADE
(Along Existing ℄ Michigan City Road)



LOCATION SKETCH

GENERAL PLAN & ELEVATION
RETAINING WALL ALONG SHARED USE PATH
MICHIGAN CITY ROAD OVER I-94
(BISHOP FORD FREEWAY)
COOK COUNTY
STATION 394+50 TO 396+60

8-29-2023

WALL TYPE STUDY - EXHIBIT A

DELTA ENGINEERING GROUP, LLC
111 W JACKSON BLVD, SUITE 910
CHICAGO, IL 60604
T 312.377.7780, F 312.427.6145

USER NAME = $USER$	DESIGNED -	REVISED -
	DRAWN -	REVISED -
PLOT SCALE = $SCALE$	CHECKED -	REVISED -
PLOT DATE = $DATE$	DATE - 5/15/2023	REVISED -

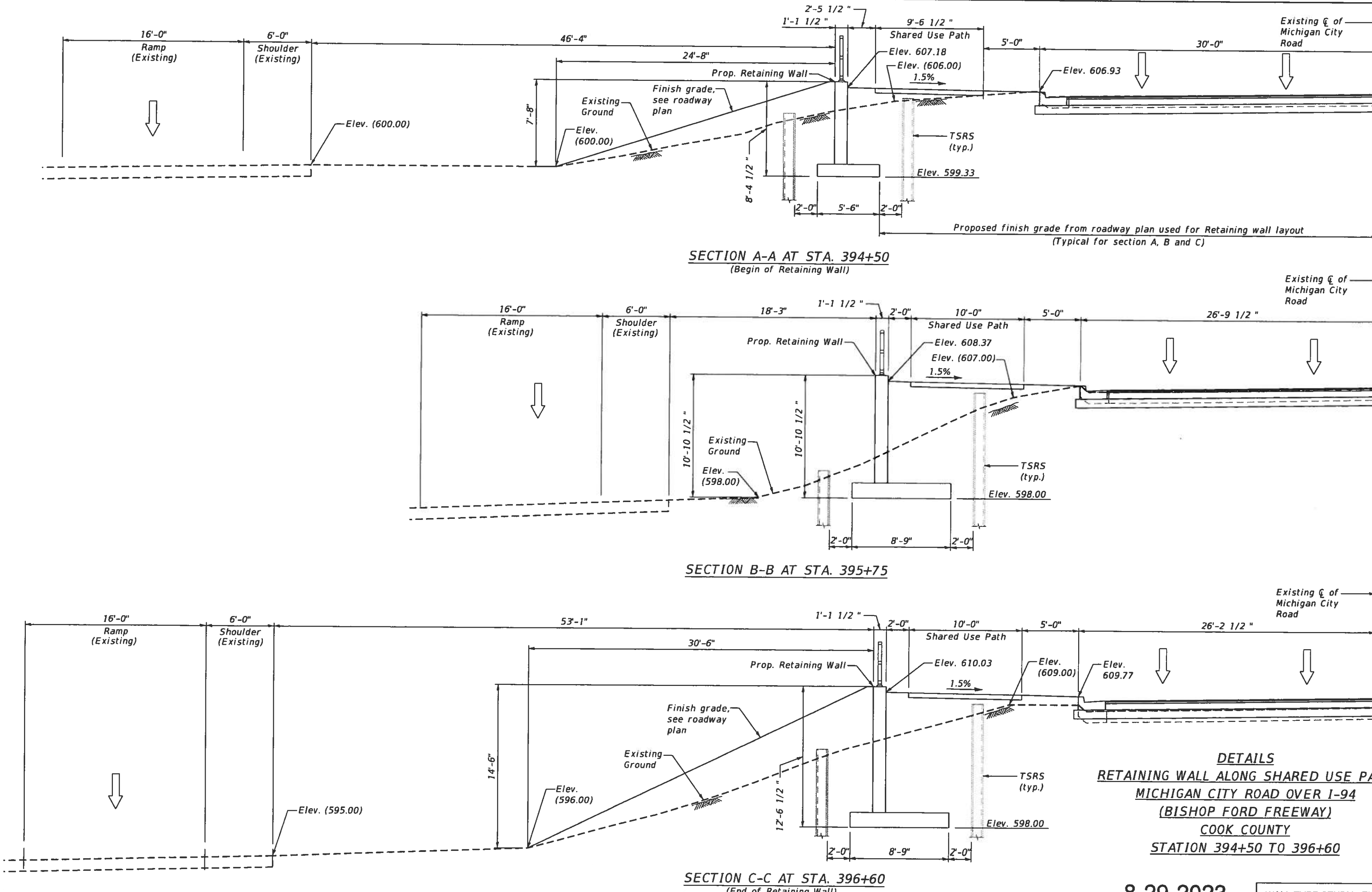
STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

SCALE: | SHEET OF SHEETS | STA. TO STA.

F.A.I. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
I-94	XXXXXXXXXXX	COOK	3	1
		CONTRACT NO. XXXX		

ILLINOIS FED. AID PROJECT

MODEL: $MODELNAME$
FILE NAME: $FILE$



DETAILS
RETAINING WALL ALONG SHARED USE PATH
MICHIGAN CITY ROAD OVER I-94
(BISHOP FORD FREEWAY)
COOK COUNTY
STATION 394+50 TO 396+60

8-29-2023

WALL TYPE STUDY - EXHIBIT A

MODEL: $MODELNAME$
FILE NAME: $FILES$

DELTA ENGINEERING GROUP, LLC
111 W JACKSON BLVD, SUITE 930
CHICAGO, IL 60604
T 312.377.7780, F 312.427.6145

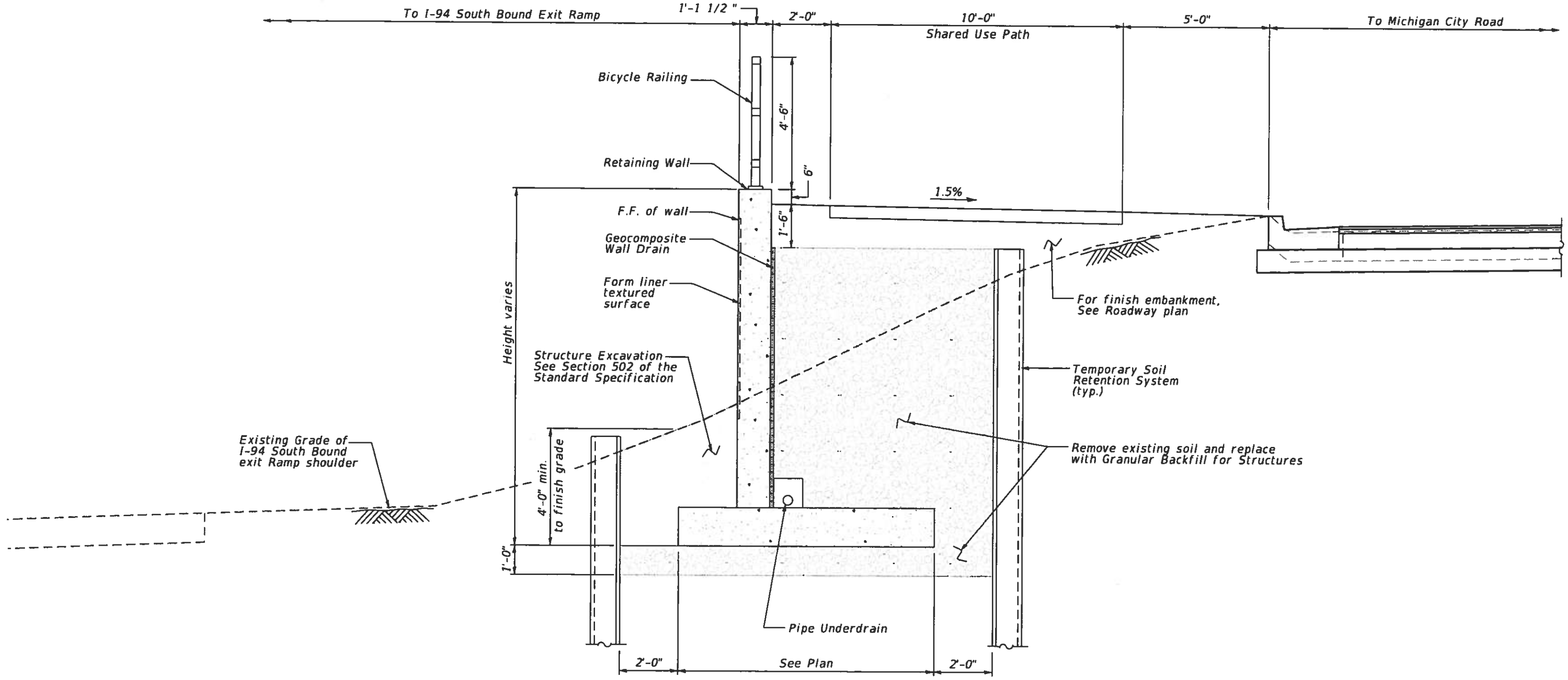
USER NAME = $USER$	DESIGNED -	REVISED -	
	DRAWN -	REVISED -	
PLOT SCALE = $SCALE$	CHECKED -	REVISED -	
PLOT DATE = $DATE$	DATE - 5/15/2023	REVISED -	

STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

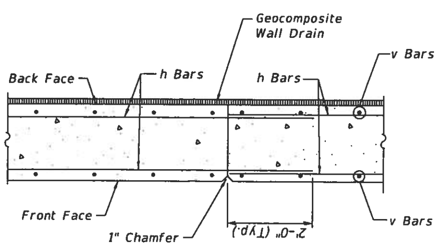
SCALE: | SHEET OF SHEETS | STA. | TO STA.

F.A.I. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
I-94	XXXXXXXXXXX	COOK	3	2
		CONTRACT NO. XXXX		

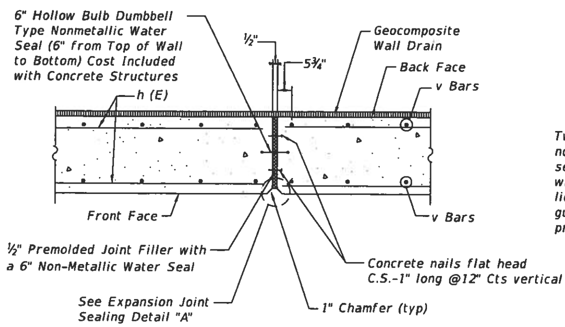
ILLINOIS | FED. AID PROJECT



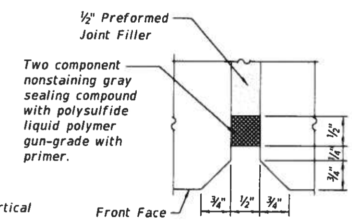
TYPICAL WALL SECTION
(Looking East)



WALL CONSTRUCTION JOINT DETAIL



WALL EXPANSION JOINT DETAIL



EXPANSION JOINT
SEALING DETAIL A

DETAILS
RETAINING WALL ALONG SHARED USE PATH
MICHIGAN CITY ROAD OVER I-94
(BISHOP FORD FREEWAY)
COOK COUNTY
STATION 394+50 TO 396+60

8-29-2023

WALL TYPE STUDY - EXHIBIT A

MODEL: $MODELNAME$
FILE NAME: $FILE$

DELTA ENGINEERING GROUP, LLC
111 W JACKSON BLVD, SUITE 910
CHICAGO, IL 60604
T 312.377.7700, F 312.427.6145

USER NAME = $USER$	DESIGNED -	REVISED -	STATE OF ILLINOIS DEPARTMENT OF TRANSPORTATION
	DRAWN -	REVISED -	
PLOT SCALE = $SCALE$	CHECKED -	REVISED -	
PLOT DATE = $DATE$	DATE - 5/15/2023	REVISED -	

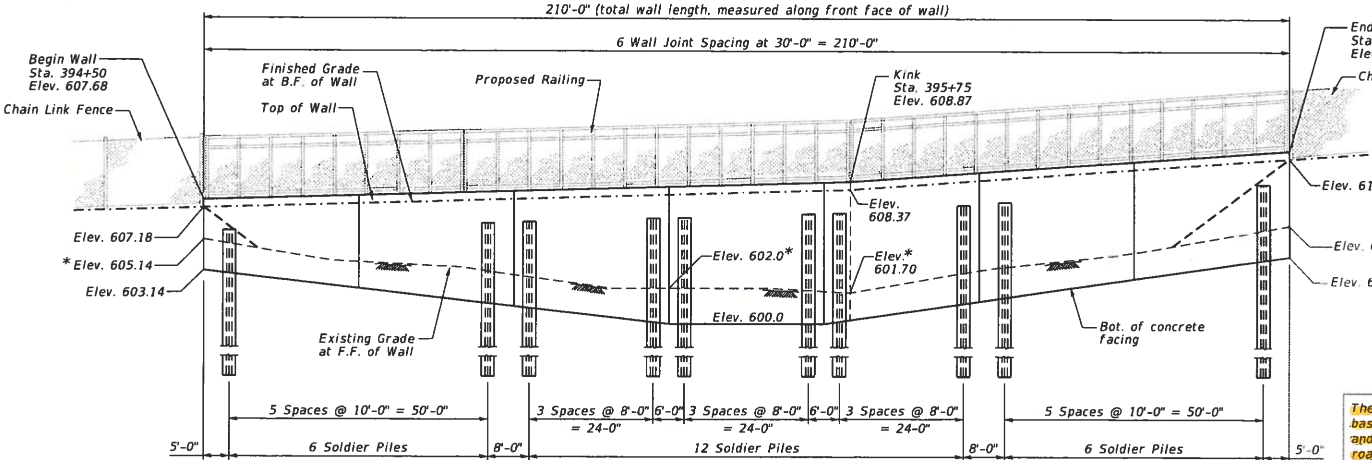
SCALE: | SHEET OF SHEETS | STA. TO STA.

F.A.I. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
I-94	XXXXXXXXXXX	COOK	3	3
		CONTRACT NO. XXXX		

ILLINOIS | FED. AID PROJECT

Bench Mark: Chiseled square cut in Northeast corner of wingwall at Northwest corner of Michigan City Road deck Elev. 613.98.

Existing Structure: None

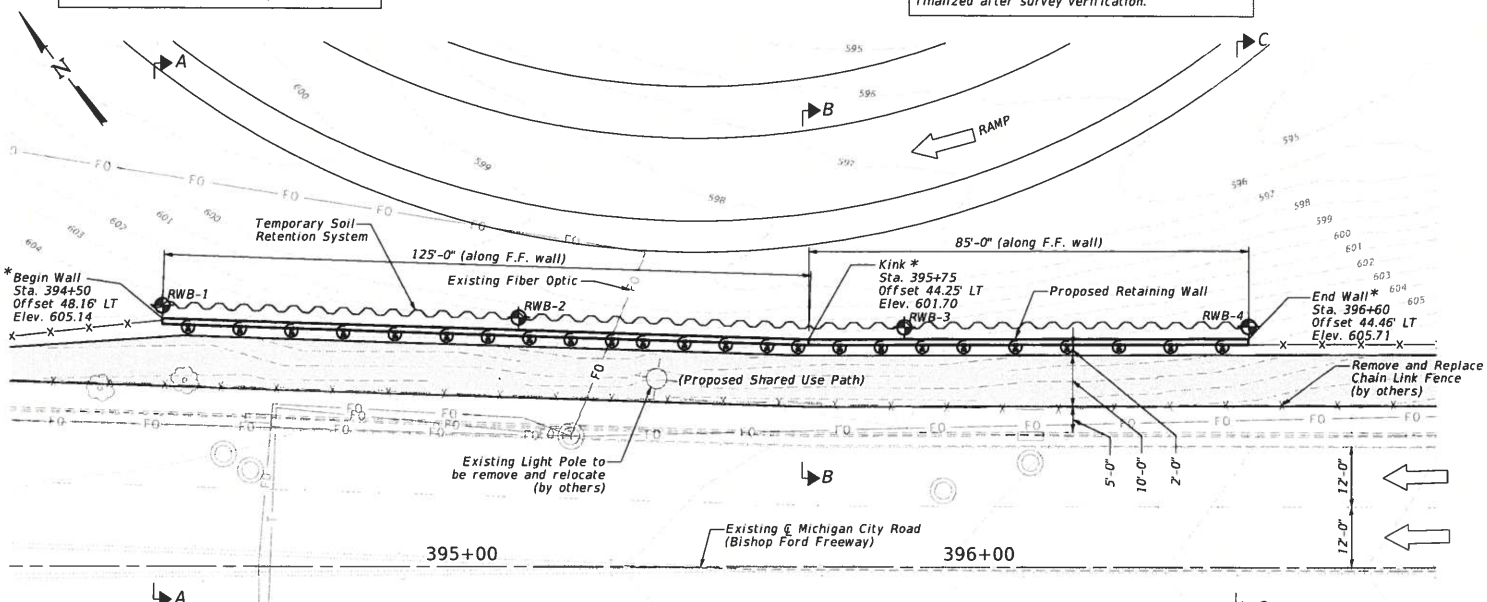


ELEVATION PROFILE
(Looking @ B.F. Wall)

Surveyor verify the (*) elevation at the Front Face of Wall for finish grading.

Elevations shown on the exhibit are approximate for Wall type study purpose only. They will be finalized after survey verification.

The Retaining Wall alignment and elevation are developed based on Phase I proposed Michigan City Road profile grade and existing embankment contours. They shall be checked by roadway design group for consistence with the roadway final geometry before allowed to be use for final wall TSL.

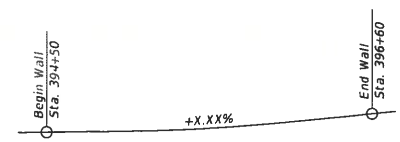


PLAN

DESIGN SPECIFICATIONS
2020 AASHTO LRFD Bridge Design Specifications, 9th Edition with 2015 Interims

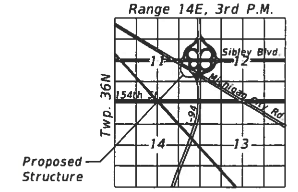
DESIGN STRESSES
FIELD UNITS
f'c = 3,500 psi
fy = 60,000 psi (Reinforcement)
fy = 50,000 psi (M270 Grade 50)

HIGHWAY CLASSIFICATION
Michigan City Road
Functional Class: Other Principal Arterial
ADT: 9,300 (2014); 9,579 (2032)
ADTT: 279 (2014); 287 (2032)
DHV: 930 (2014)
Design Speed: 35 m.p.h.
Posted Speed: 35 m.p.h.
Two-Way Traffic
Directional Distribution: 50:50



PROPOSED FROFILE GRADE
(Along Existing ℄ Michigan City Road)

Range 14E, 3rd P.M.



LOCATION SKETCH

GENERAL PLAN & ELEVATION
RETAINING WALL ALONG SHARED USE PATH
MICHIGAN CITY ROAD OVER I-94
(BISHOP FORD FREEWAY)
COOK COUNTY
STATION 394+50 TO 396+60

8-29-2023

WALL TYPE STUDY - EXHIBIT B

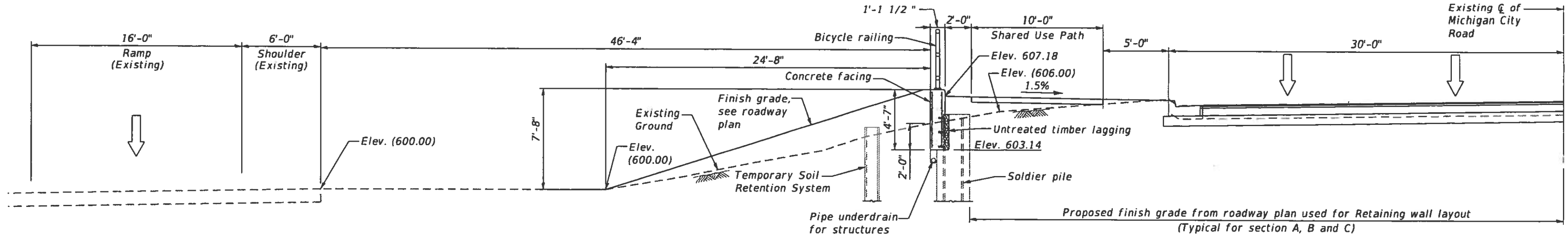
DELTA ENGINEERING GROUP, LLC 111 W JACKSON BLVD, SUITE 910 CHICAGO, IL 60604 T 312.377.7780, F 312.427.6145	USER NAME = $USER$	DESIGNED -	REVISED -
		DRAWN -	REVISED -
	PLOT SCALE = $SCALE$	CHECKED -	REVISED -
	PLOT DATE = $DATE$	DATE - 5/15/2023	REVISED -

STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

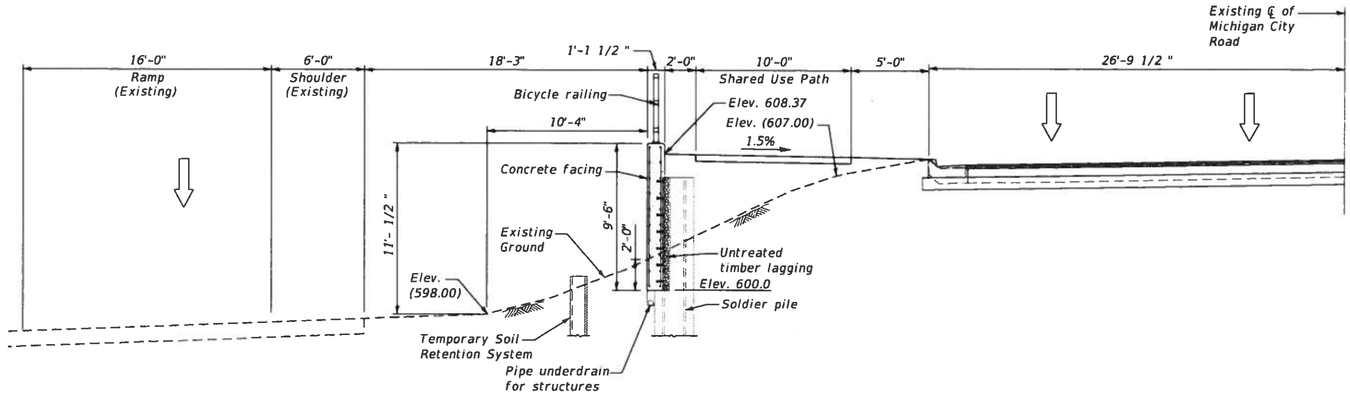
SCALE: | SHEET | OF | SHEETS | STA. | TO STA.

F.A.I. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
I-94	XXXXXXXXXXX	COOK	3	1
		CONTRACT NO. XXXX		

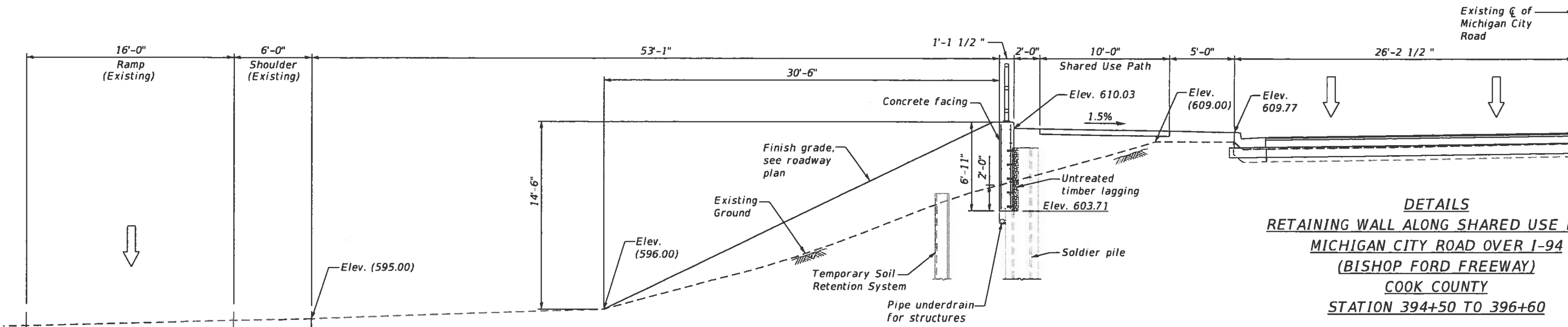
ILLINOIS | FED. AID PROJECT



SECTION A-A AT STA. 394+50
(Begin of Retaining Wall)



SECTION B-B AT STA. 395+75



SECTION C-C AT STA. 396+60
(End of Retaining Wall)

DETAILS
RETAINING WALL ALONG SHARED USE PATH
MICHIGAN CITY ROAD OVER I-94
(BISHOP FORD FREEWAY)
COOK COUNTY
STATION 394+50 TO 396+60

8-29-2023

WALL TYPE STUDY - EXHIBIT B

MODEL: $MODELNAME$
FILE NAME: $FILEL$

DELTA ENGINEERING GROUP, LLC
111 W JACKSON BLVD, SUITE 910
CHICAGO, IL 60604
T 312.377.7700, F 312.427.6145

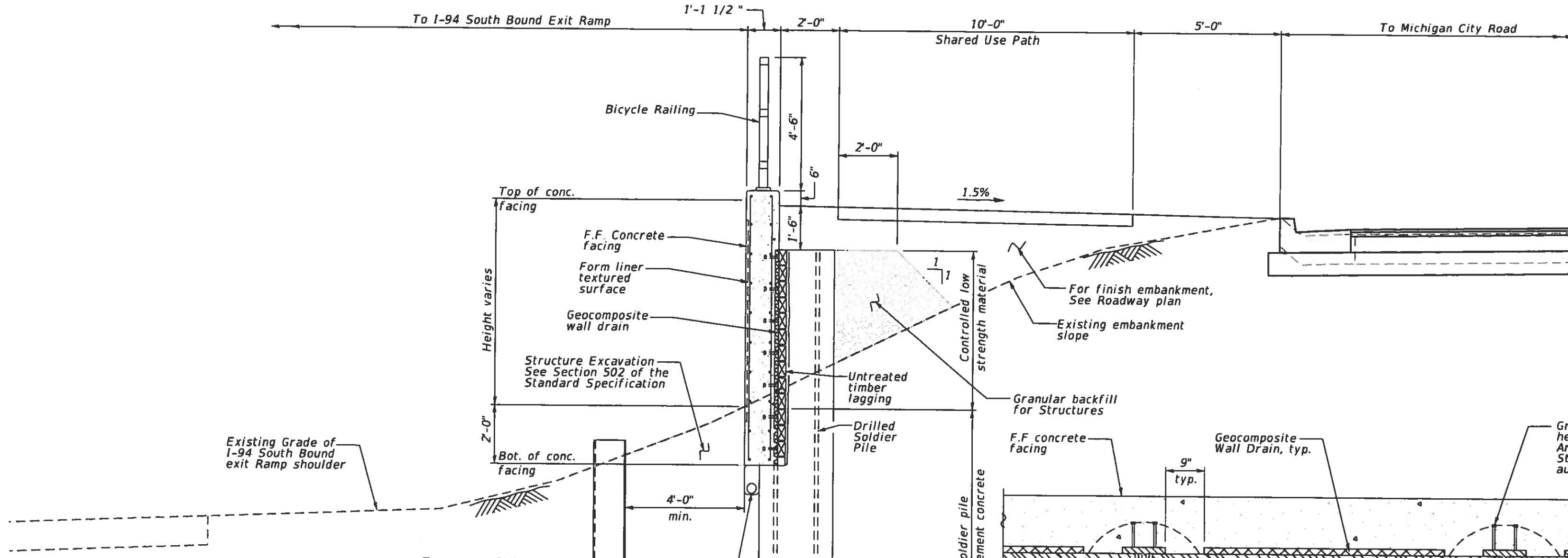
USER NAME = $USER$		DESIGNED -	REVISED -
		DRAWN -	REVISED -
PLOT SCALE = $SCALE$		CHECKED -	REVISED -
PLOT DATE = $DATE$		DATE - 5/15/2023	REVISED -

STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

SCALE: | SHEET OF SHEETS | STA. TO STA.

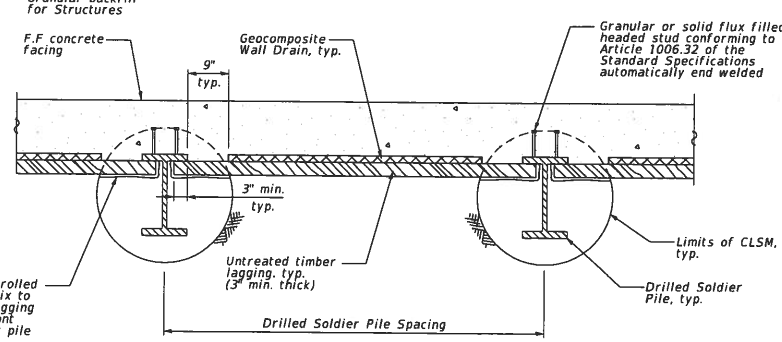
F.A.I. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
I-94	XXXXXXXXXXX	COOK	3	2
		CONTRACT NO. XXXX		

ILLINOIS FED. AID PROJECT



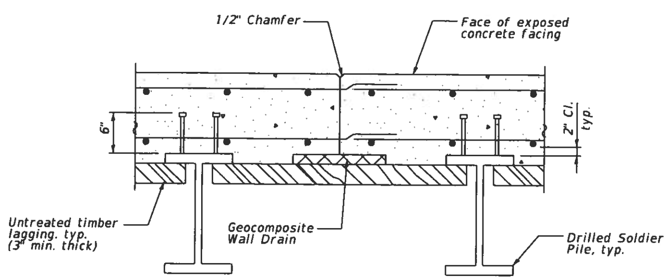
TYPICAL SECTION THRU SOLDIER PILE WALL

(Looking East)

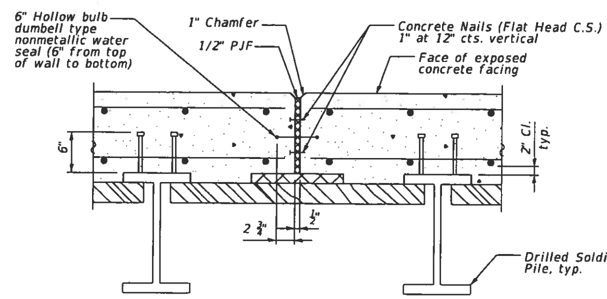


HORIZONTAL SECTION THRU SOLDIER WALL

The Contractor is responsible for the design and performance of the lagging using no less than a 3 in. nominal rough-sawn thickness and timber with minimum allowable bending stress of 1000 psi. A nominal thickness up to 6 in. is expected in some portions of the wall.



CONSTRUCTION JOINT DETAILS



EXPANSION JOINT DETAILS

DETAILS

RETAINING WALL ALONG SHARED USE PATH

MICHIGAN CITY ROAD OVER I-94

(BISHOP FORD FREEWAY)

COOK COUNTY

STATION 394+50 TO 396+60

8-29-2023

WALL TYPE STUDY - EXHIBIT B

MODEL: $MODELNAME$
FILE NAME: $FILEL$

DELTA ENGINEERING GROUP, LLC
111 W JACKSON BLVD, SUITE 910
CHICAGO, IL 60604
T 312.377.7700, F 312.427.6145

USER NAME = $USER$	DESIGNED -	REVISED -	
	DRAWN -	REVISED -	
PLOT SCALE = $SCALE$	CHECKED -	REVISED -	
PLOT DATE = $DATE$	DATE - 5/15/2023	REVISED -	

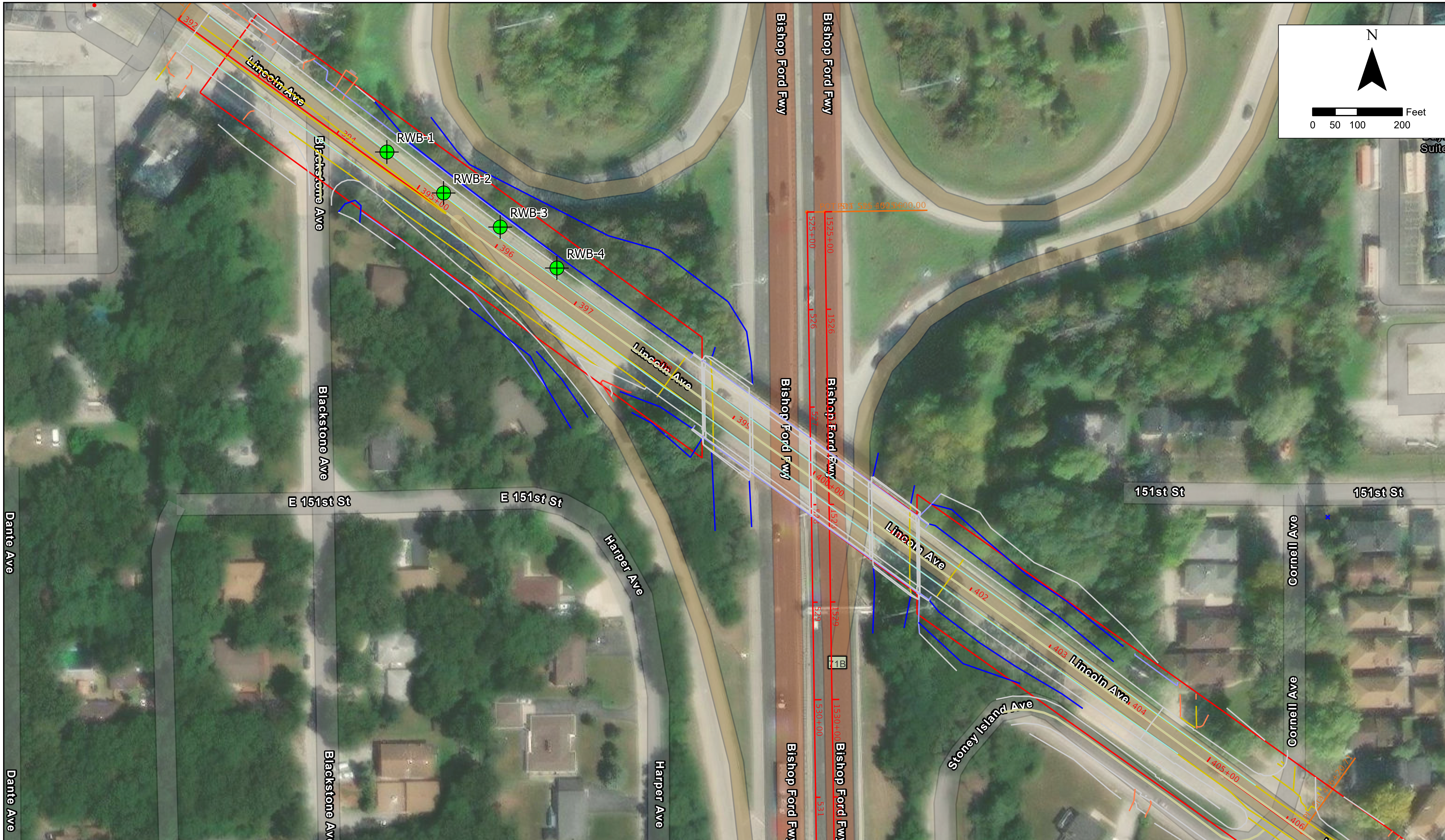
STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

SCALE: | SHEET OF SHEETS | STA. | TO STA.

F.A.I. RTE.	SECTION	COUNTY	TOTAL SHEETS	SHEET NO.
I-94	XXXXXXXXXXX	COOK	3	3
		CONTRACT NO. XXXX		
	ILLINOIS	FED. AID PROJECT		

Appendix B

Soil Boring Location Plan and Subsurface Profile



DRAWN BY	KN	**DATE**	10/4/2023
CHECKED BY	MZ	**DATE**	10/4/2023

GSG CONSULTANTS, INC.
735 Remington Road, Schaumburg, IL 60173
Tel: 630.994.2600, www.gsg-consultants.com

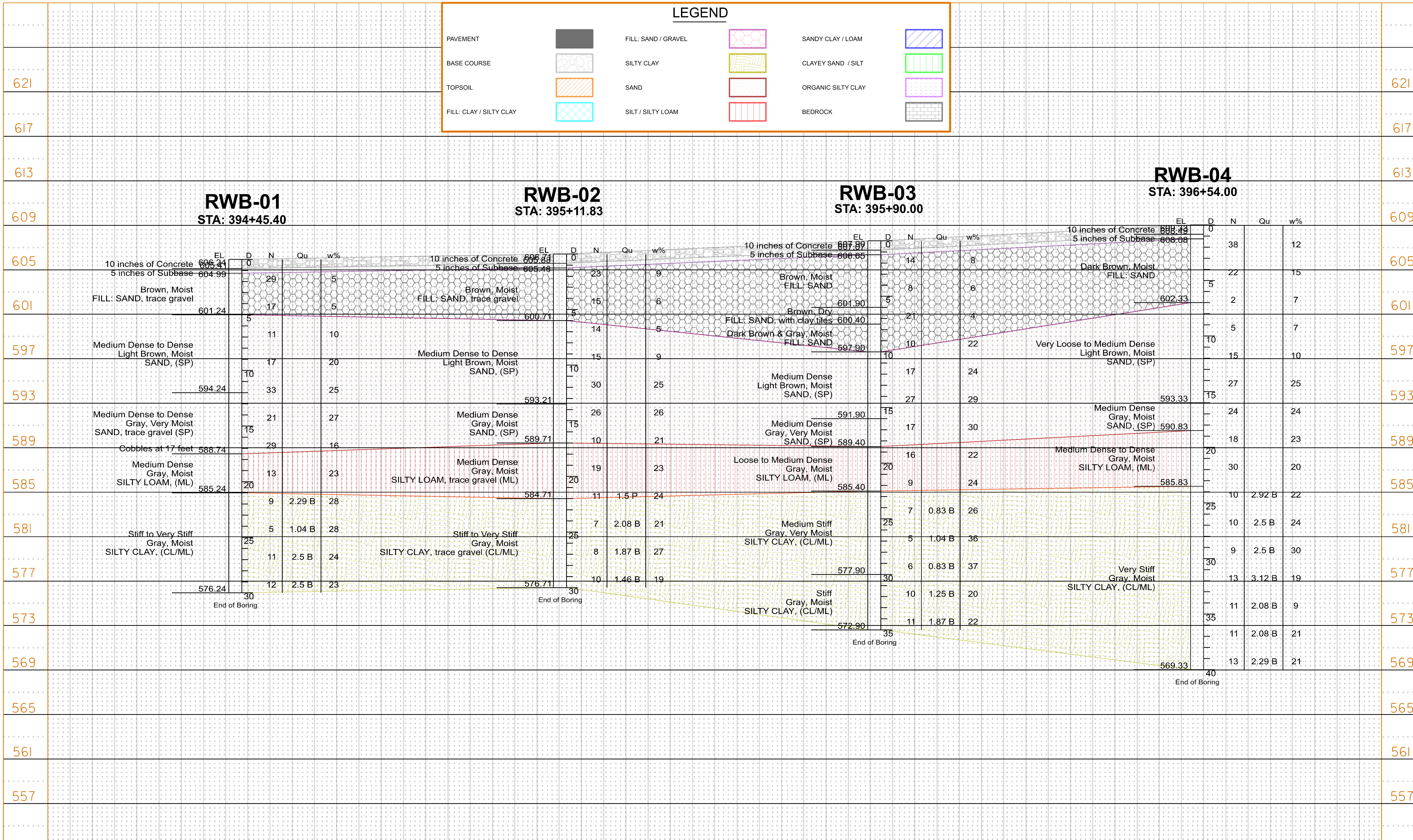
Illinois Department of Transportation

DELTA ENGINEERING GROUP

MICHIGAN CITY ROAD OVER I-94

EXHIBIT 2: RETAINING WALL BORING LOCATION PLAN

SHEET NO.
-



GSG CONSULTANTS, INC.
735 E. REMINGTON RD, SCHAUMBURG, IL 60173
TEL: +1630.994.2600 | WWW.GSG-CONSULTANTS.COM

USER NAME = KN		DESIGNED - KN	
SHEET SIZE = 11x17		DRAWN - KN	
PLOT SCALE = NTS		CHECKED - AA	
PLOT DATE = 10.16.2023		DATE - 10.16.2023	

DELTA ENGINEERING 204-001

SUBSURFACE PROFILES - RETAINING WALL
MICHIGAN CITY ROAD OVER I-94

SCALE: XX | SHEET OF SHEETS | STA. TO STA.

F.A. RTE. | SECTION | COUNTY | TOTAL SHEETS | SHEET NO.
CONTRACT NO.
ILLINOIS | FED. AID PROJECT

FILE NAME = $FILE$
PEN TABLE = $PENTBL$
PLOT DATE = $DATE$
TIME = $TIME$
SHEET SIZE = $SHEETSIZE$
PLOT SCALE = $SCALE$
USER NAME = $USER$

Appendix C
Soil Boring Logs

Illinois Department of Transportation
Division of Highways
GSG

SOIL BORING LOG

Date 9/28/23

ROUTE Michigan City Rd **DESCRIPTION** Retaining Wall Boring **LOGGED BY** AA

SECTION Michigan City Rd **LOCATION** , SEC. , TWP. , RNG. ,
Latitude 41.6218694, **Longitude** -087.5805250

COUNTY COOK **DRILLING RIG** CME 75 **HAMMER TYPE** AUTO
DRILLING METHOD HSA **HAMMER EFF (%)** 79.8

STRUCT. NO.
Station

BORING NO. RWB-01
Station 394+52.69
Offset 15.20ft LT
Ground Surface Elev. 606.24 ft

Surface Water Elev. N/A ft
Stream Bed Elev. N/A ft

Groundwater Elev.:
First Encounter 595.2 ft ▼
Upon Completion N/A ft
After N/A **Hrs.** N/A ft

Description	Elev.	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
10 inches of Concrete	605.41				
5 inches of Subbase	604.99				
Brown, Moist FILL: SAND, trace gravel			9 14 15		5
			5 7 10		5
	601.24	-5			
Medium Dense to Dense Light Brown, Moist to Wet SAND, (SP)			3 5 6		10
		-10	4 7 10		20
		▼	6 16 17		25
	594.24				
Medium Dense to Dense Gray, Wet SAND, trace gravel (SP)		-15	6 12 9		27
Cobbles at 17 feet	588.74		7 14 15		16
Medium Dense Gray, Moist SILTY LOAM, (ML)		-20	4 6 7		23
	585.24				
Stiff to Very Stiff Gray, Moist to Very Moist SILTY CLAY, (CL/ML)			3 3 6	2.3 B	28
		-25	2 3 2	1.0 B	28
			3 4 7	2.5 B	24
	576.24	-30	4 6 6	2.5 B	23
End of Boring		-35			
		-40			

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

Illinois Department of Transportation
Division of Highways
GSG

SOIL BORING LOG

Date 9/28/23

ROUTE	Michigan City Rd	**DESCRIPTION**	Retaining Wall Boring	**LOGGED BY**	AA
SECTION	Michigan City Rd	**LOCATION**	, SEC. , TWP. , RNG. , Latitude 41.6217528, Longitude -087.5803139		
COUNTY	COOK	**DRILLING RIG**	CME 75	**HAMMER TYPE**	AUTO
		DRILLING METHOD	HSA	**HAMMER EFF (%)**	79.8

STRUCT. NO.		**Surface Water Elev.**	N/A ft
Station		**Stream Bed Elev.**	N/A ft
BORING NO.	RWB-02	**Groundwater Elev.:**	
Station	395+23.26	**First Encounter**	595.7 ft ▼
Offset	15.21ft LT	**Upon Completion**	N/A ft
Ground Surface Elev.	606.71 ft	**After** N/A **Hrs.**	N/A ft

Description	Elev.	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
10 inches of Concrete	605.88				
5 inches of Subbase	605.46				
Brown, Moist FILL: SAND, trace gravel			6 11 12		9
		-5	3 6 9		6
	600.71				
Medium Dense to Dense Light Brown, Moist to Wet SAND, (SP)			5 7 7		5
		-10	5 7 8		9
▼			9 14 16		25
	593.21				
Medium Dense Gray, Wet SAND, (SP)		-15	5 12 14		26
	589.71		5 6 4		21
Medium Dense Gray, Moist SILTY LOAM, trace gravel (ML)		-20	8 10 9		23
Medium Dense Gray, Moist SILTY LOAM, trace gravel (ML) *(continued)*	584.71		6 7 4	1.5 P	24
Stiff to Very Stiff Gray, Moist to Very Moist SILTY CLAY, trace gravel (CL/ML)		-25	1 2 5	2.1 B	21
			4 3 5	1.9 B	27
	576.71	-30	2 4 6	1.5 B	19
End of Boring		-35			
		-40			

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

BBS, form 137 (Rev. 8-99)

Illinois Department of Transportation
Division of Highways
GSG

SOIL BORING LOG

Date 9/28/23

ROUTE Michigan City Rd **DESCRIPTION** Retaining Wall Boring **LOGGED BY** AA

SECTION Michigan City Rd **LOCATION** , SEC. , TWP. , RNG. ,
Latitude 41.6216556, **Longitude** -087.5801028

COUNTY COOK **DRILLING RIG** CME 75 **HAMMER TYPE** AUTO
DRILLING METHOD HSA **HAMMER EFF (%)** 79.8

STRUCT. NO.
Station

BORING NO. RWB-03
Station 395+90.61
Offset 21.00ft LT
Ground Surface Elev. 607.90 ft

Surface Water Elev. N/A ft
Stream Bed Elev. N/A ft

Groundwater Elev.:
First Encounter 595.9 ft ▼
Upon Completion N/A ft
After N/A **Hrs.** N/A ft

Description	Elev.	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
10 inches of Concrete	607.07				
5 inches of Subbase	606.65		9		
Brown, Moist FILL: SAND			7 7		8
			5 4 4		6
		-5			
	601.90				
Brown, Dry FILL: SAND, with clay tiles fragments	600.40		3 1 20		4
Dark Brown & Gray, Wet FILL: SAND	597.90	-10	4 4 6		22
Medium Dense Light Brown, Wet SAND, (SP)		▼	5 8 9		24
		-15	5 12 15		29
	591.90				
Medium Dense Gray, Wet SAND, (SP)	589.40		5 6 11		30
Loose to Medium Dense Gray, Very Moist SILTY LOAM, (ML)		-20	7 7 9		22

Description	Elev.	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
Loose to Medium Dense Gray, Very Moist SILTY LOAM, (ML) *(continued)*	585.40		4 5 4		24
Medium Stiff Gray, Very Moist SILTY CLAY, (CL/ML)		-25	WoH 3 4	0.8 B	26
			WoH 2 3	1.0 B	36
	577.90	-30	WoH 2 4	0.8 B	37
Stiff Gray, Moist SILTY CLAY, (CL/ML)			3 5 5	1.3 B	20
	572.90	-35	3 5 6	1.9 B	22
End of Boring					
		-40			

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

Illinois Department of Transportation
Division of Highways
GSG

SOIL BORING LOG

Date 9/28/23

ROUTE Michigan City Rd **DESCRIPTION** Retaining Wall Boring **LOGGED BY** AA

SECTION Michigan City Rd **LOCATION** , SEC. , TWP. , RNG. ,
Latitude 41.6215389, **Longitude** -087.5798917

COUNTY COOK **DRILLING RIG** CME 75 **HAMMER TYPE** AUTO
DRILLING METHOD HSA **HAMMER EFF (%)** 79.8

STRUCT. NO.
Station

BORING NO. RWB-04
Station 396+62.14
Offset 21.00ft LT
Ground Surface Elev. 609.33 ft

Surface Water Elev. N/A ft
Stream Bed Elev. N/A ft

Groundwater Elev.:
First Encounter 595.8 ft ▼
Upon Completion N/A ft
After N/A **Hrs.** N/A ft

Description	Elev.	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
10 inches of Concrete	608.49				
5 inches of Subbase	608.08		14		
Dark Brown, Moist FILL: SAND			19		12
			19		
			6		
			11		15
		-5	11		
			3		
	602.33		1		7
Very Loose to Medium Dense Light Brown, Moist to Wet SAND, (SP)			1		
			2		
			2		7
		-10	3		
			5		
			6		10
			9		
		▼	4		
			10		25
		-15	17		
	593.33		8		
Medium Dense Gray, Wet SAND, (SP)			13		24
			11		
	590.83		4		
Medium Dense to Dense Gray, Moist to Very Moist SILTY LOAM, (ML)			7		23
		-20	11		
Medium Dense to Dense Gray, Moist to Very Moist SILTY LOAM, (ML) *(continued)*			9		
			16		20
			14		
	585.83		4		
Very Stiff Gray, Moist to Very Moist SILTY CLAY, (CL/ML)			4	2.9	22
		-25	6	B	
			3		
			4	2.5	24
			6	B	
			4		
			4	2.5	30
		-30	5	B	
			5		
			5	3.1	19
			8	B	
			3		
			5	2.1	9
		-35	6	B	
			3		
			4	2.1	21
			7	B	
			3		
			6	2.3	21
	569.33	-40	7	B	

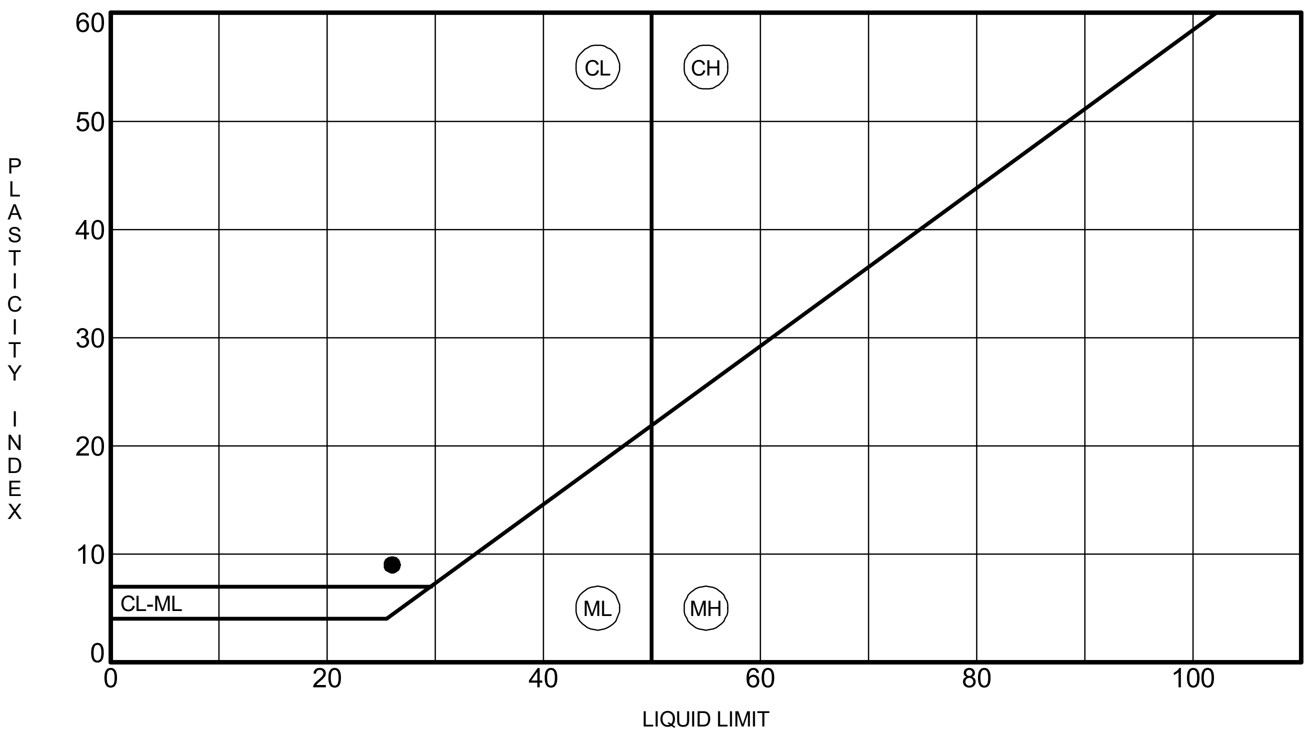
End of Boring

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

BBS, form 137 (Rev. 8-99)

APPENDIX D

LABORATORY TEST RESULTS



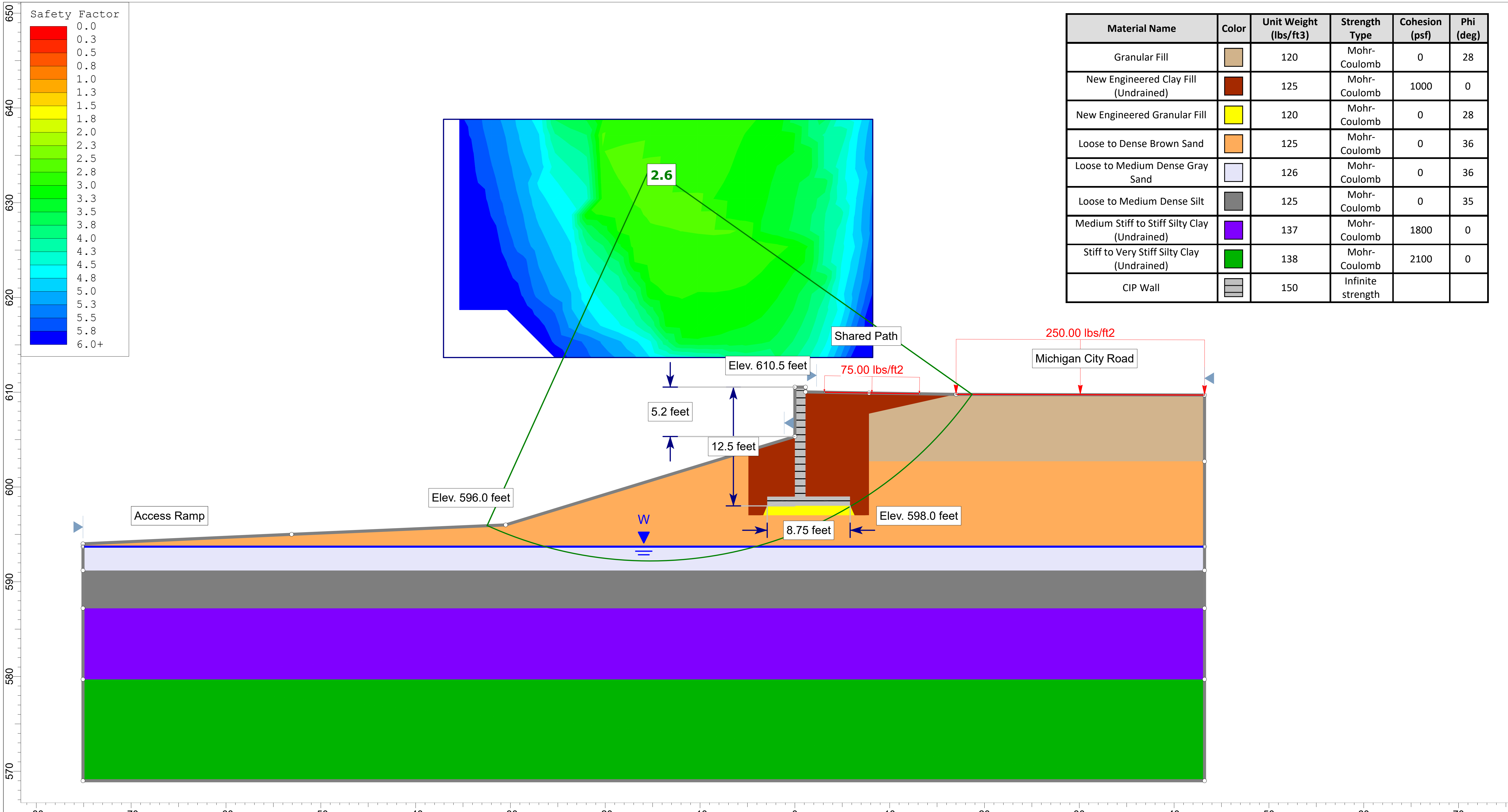
	Specimen Identification		LL	PL	PI	Fines	Classification
●	**RWB-03**	**23.50**	**26.0**	**17.0**	**9.0**		

Illinois Department of Transportation
Division of Highways
GSG

ATTERBERG LIMITS' RESULTS

Route: Michigan City Rd
Section: Michigan City Rd
County: COOK

Appendix E
Slope Stability Analysis Exhibits

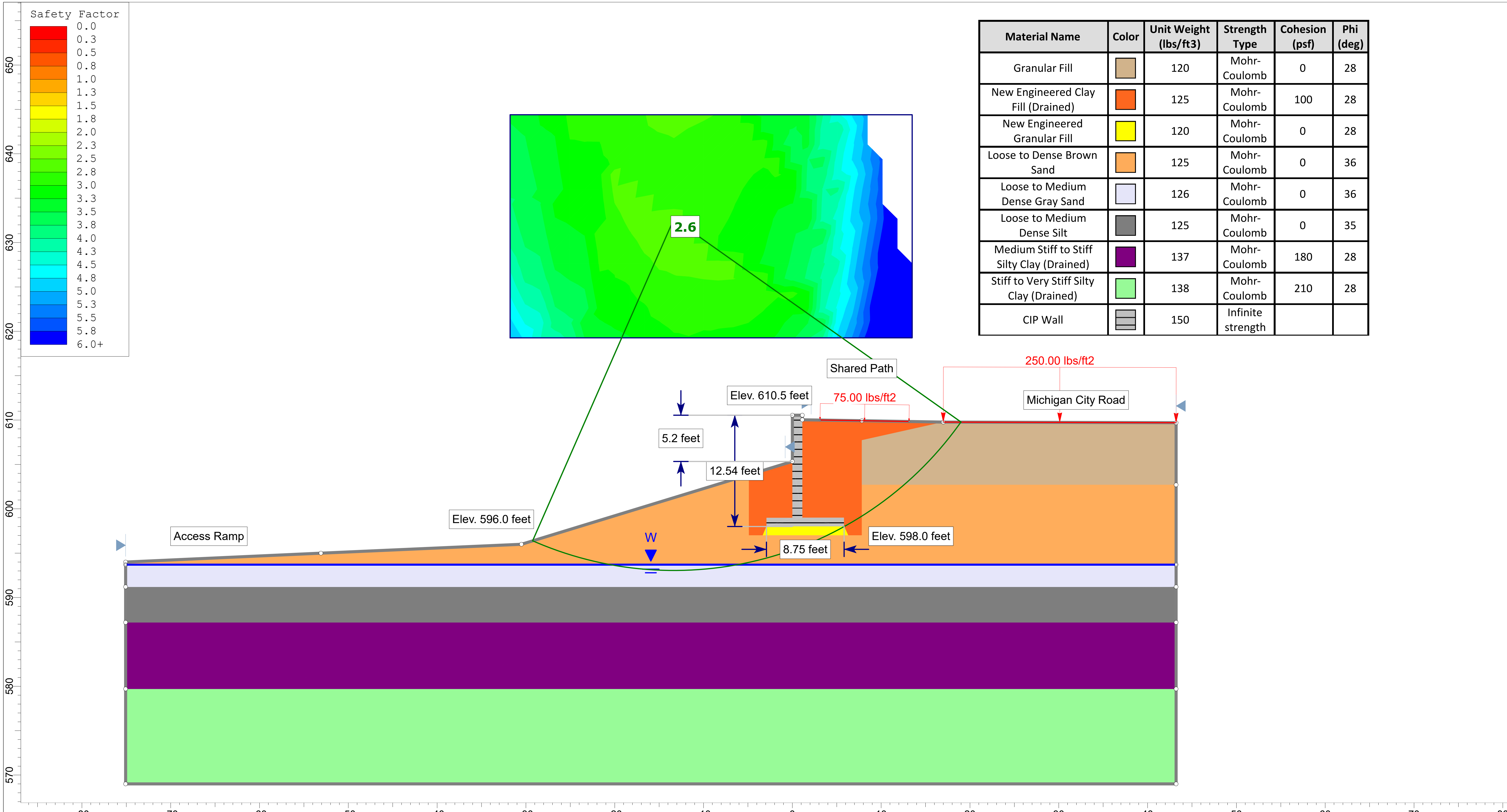


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Granular Fill		120	Mohr-Coulomb	0	28
New Engineered Clay Fill (Undrained)		125	Mohr-Coulomb	1000	0
New Engineered Granular Fill		120	Mohr-Coulomb	0	28
Loose to Dense Brown Sand		125	Mohr-Coulomb	0	36
Loose to Medium Dense Gray Sand		126	Mohr-Coulomb	0	36
Loose to Medium Dense Silt		125	Mohr-Coulomb	0	35
Medium Stiff to Stiff Silty Clay (Undrained)		137	Mohr-Coulomb	1800	0
Stiff to Very Stiff Silty Clay (Undrained)		138	Mohr-Coulomb	2100	0
CIP Wall		150	Infinite strength		

GSG CONSULTANTS, INC.
735 Remington Road, Schaumburg, IL 60173
Tel: 630.994.2600, www.gsg-consultants.com

SLIDEINTERPRET 9.018

Project	PTB 204-001 Michigan City Road - Retaining Wall - STA. 396+60		
Analysis Description	Exhibit a - Circular Failure Short Term (undrained) -CIP Wall		
Drawn By	AA	*Company*	GSG Consultants, Inc.
Date	10/06/2023, 11:17:46 AM	*File Name*	Slope Stability CIP v2 (Slope Study).slmd

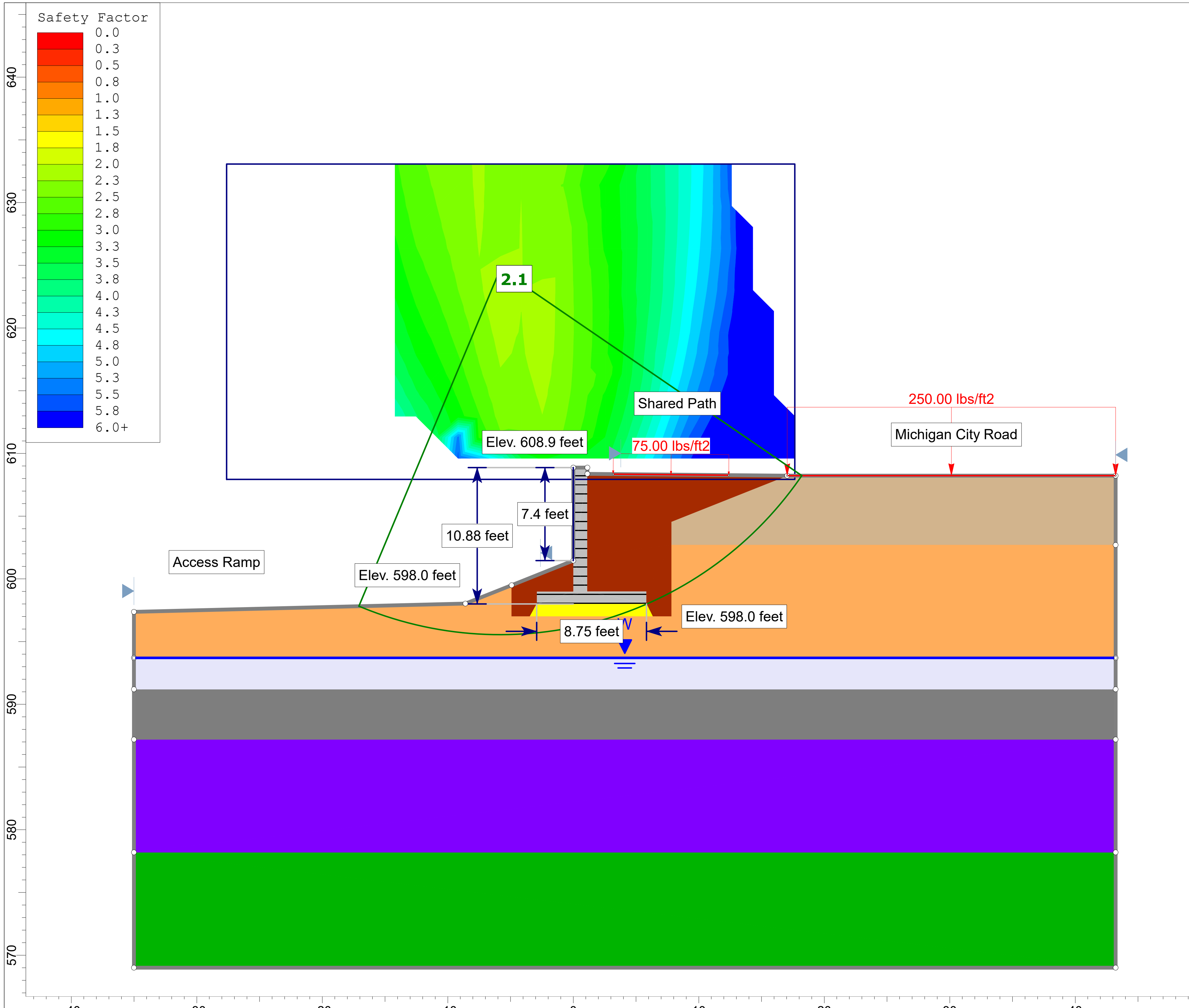


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Granular Fill		120	Mohr-Coulomb	0	28
New Engineered Clay Fill (Drained)		125	Mohr-Coulomb	100	28
New Engineered Granular Fill		120	Mohr-Coulomb	0	28
Loose to Dense Brown Sand		125	Mohr-Coulomb	0	36
Loose to Medium Dense Gray Sand		126	Mohr-Coulomb	0	36
Loose to Medium Dense Silt		125	Mohr-Coulomb	0	35
Medium Stiff to Stiff Silty Clay (Drained)		137	Mohr-Coulomb	180	28
Stiff to Very Stiff Silty Clay (Drained)		138	Mohr-Coulomb	210	28
CIP Wall		150	Infinite strength		

GSG CONSULTANTS, INC.
735 Remington Road, Schaumburg, IL 60173
Tel: 630.994.2600, www.gsg-consultants.com

SLIDEINTERPRET 9.018

Project	PTB 204-001 Michigan City Road - Retaining Wall - STA. 396+60		
Analysis Description	Exhibit b - Circular Failure Long Term (Drained) - CIP Wall		
Drawn By	AA	Company	GSG Consultants, Inc.
Date	10/06/2023, 11:17:46 AM	File Name	Slope Stability CIP v2 (Slope Study).slmd

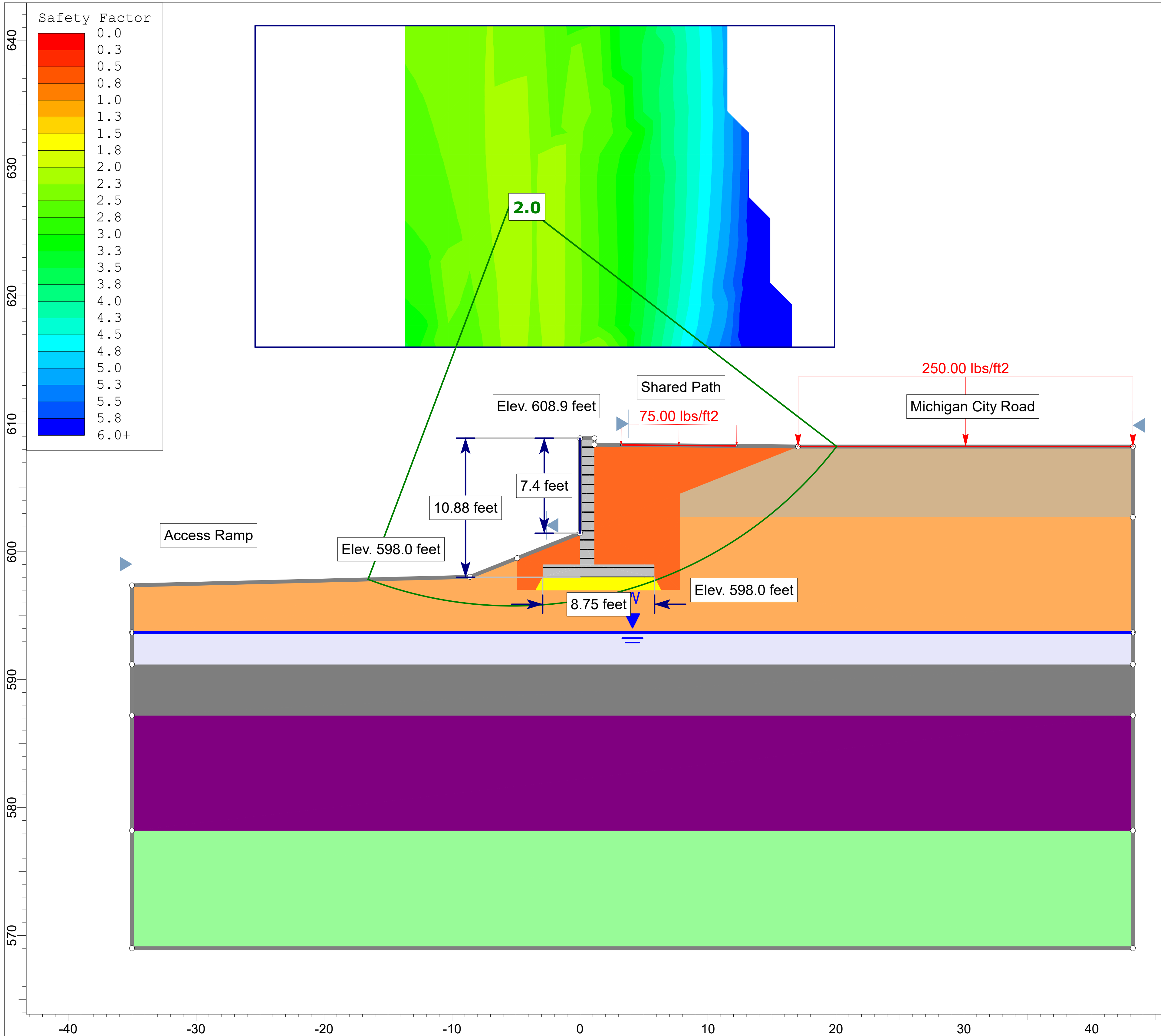


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Sand Fill		120	Mohr-Coulomb	0	28
New Engineered Clay Fill (Undrained)		125	Mohr-Coulomb	1000	0
New Engineered Granular Fill		120	Mohr-Coulomb	0	28
Loose to Dense Brown Sand		125	Mohr-Coulomb	0	36
Loose to Medium Dense Gray Sand		126	Mohr-Coulomb	0	36
Loose to Medium Dense Silt		125	Mohr-Coulomb	0	35
Medium Stiff to Stiff Sity Clay (Undrained)		137	Mohr-Coulomb	1800	0
Stiff to Very Stiff Silty Clay (Undrained)		138	Mohr-Coulomb	2100	0
CIP Wall		150	Infinite strength		

GSG CONSULTANTS, INC.
735 Remington Road, Schaumburg, IL 60173
Tel: 630.994.2600, www.gsg-consultants.com

SLIDEINTERPRET 9.018

Project	PTB 204-001 Michigan City Road - Retaining Wall - STA. 395+75		
Analysis Description	Exhibit c - Circular Failure Short Term (undrained) - CIP Wall		
Drawn By	AA	Company	GSG Consultants, Inc.
Date	10/06/2023, 11:17:46 AM	File Name	Slope Stability CIP v2 (new dim).slmd

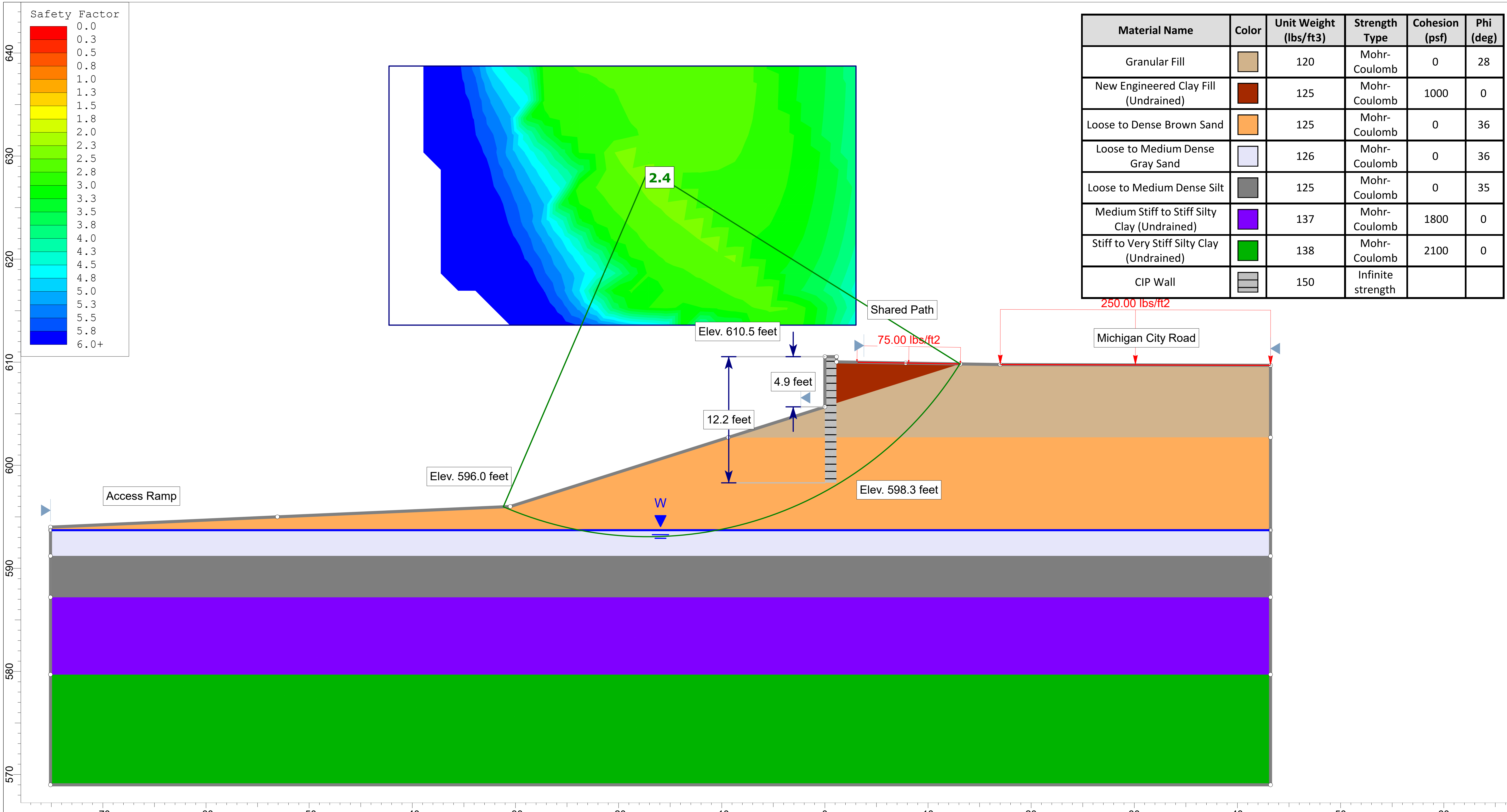


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Sand Fill		120	Mohr-Coulomb	0	28
New Engineered Clay Fill (Drained)		125	Mohr-Coulomb	100	28
New Engineered Granular Fill		120	Mohr-Coulomb	0	28
Loose to Dense Brown Sand		125	Mohr-Coulomb	0	36
Loose to Medium Dense Gray Sand		126	Mohr-Coulomb	0	36
Loose to Medium Dense Silt		125	Mohr-Coulomb	0	35
Medium Stiff to Stiff Sity Clay (Drained)		137	Mohr-Coulomb	180	28
Stiff to Very Stiff Silty Clay (Drained)		138	Mohr-Coulomb	210	28
CIP Wall		150	Infinite strength		

GSG CONSULTANTS, INC.
735 Remington Road, Schaumburg, IL 60173
Tel: 630.994.2600, www.gsg-consultants.com

SLIDEINTERPRET 9.018

Project	PTB 204-001 Michigan City Road - Retaining Wall - STA. 395+75		
Analysis Description	Exhibit d - Circular Failure Long Term (Drained) - CIP Wall		
Drawn By	AA	*Company*	GSG Consultants, Inc.
Date	10/06/2023, 11:17:46 AM	*File Name*	Slope Stability CIP v2 (new dim).slmd

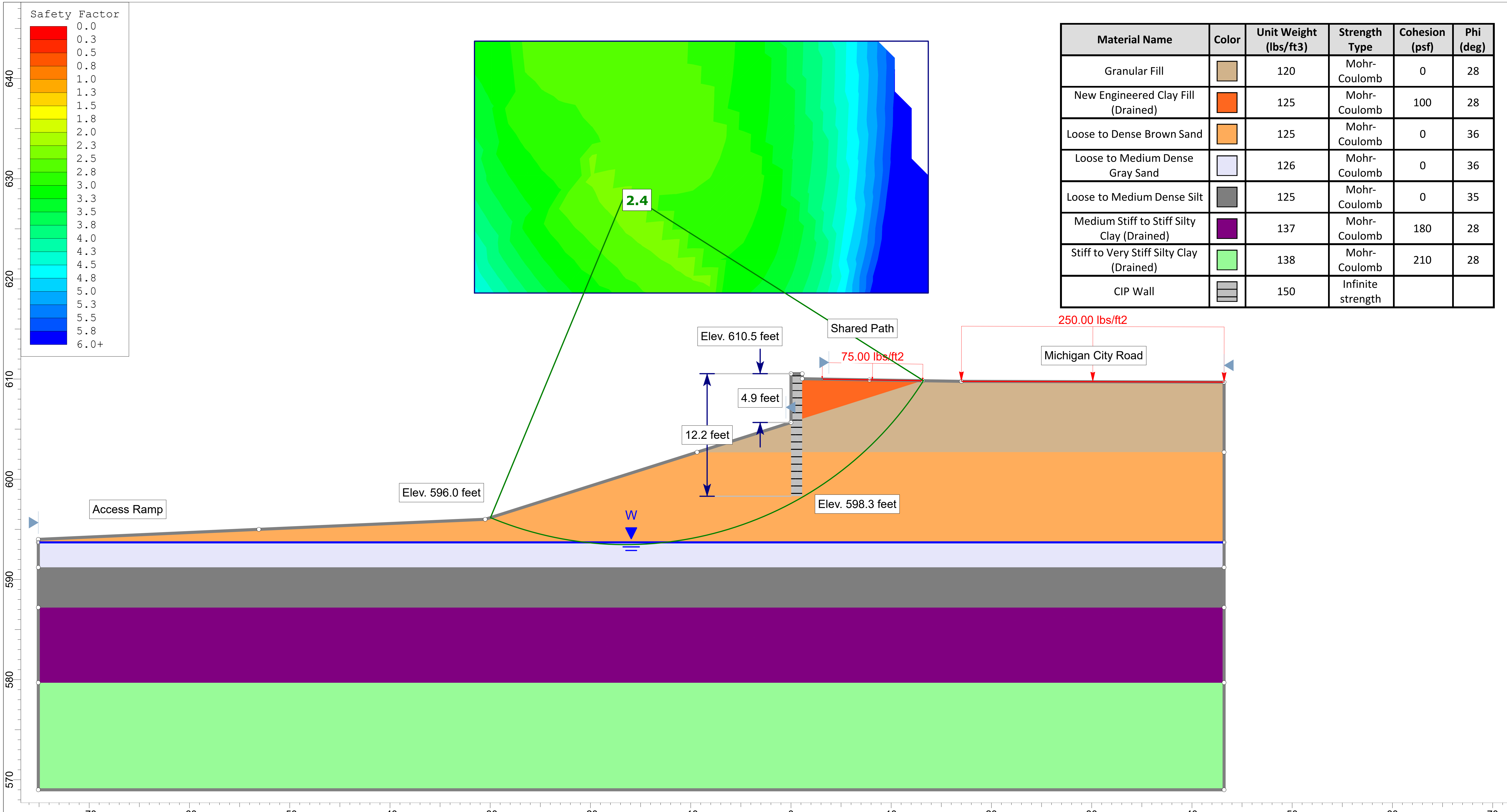


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Granular Fill		120	Mohr-Coulomb	0	28
New Engineered Clay Fill (Undrained)		125	Mohr-Coulomb	1000	0
Loose to Dense Brown Sand		125	Mohr-Coulomb	0	36
Loose to Medium Dense Gray Sand		126	Mohr-Coulomb	0	36
Loose to Medium Dense Silt		125	Mohr-Coulomb	0	35
Medium Stiff to Stiff Silty Clay (Undrained)		137	Mohr-Coulomb	1800	0
Stiff to Very Stiff Silty Clay (Undrained)		138	Mohr-Coulomb	2100	0
CIP Wall		150	Infinite strength		

GSG CONSULTANTS, INC.
735 Remington Road, Schaumburg, IL 60173
Tel: 630.994.2600, www.gsg-consultants.com

SLIDEINTERPRET 9.018

Project	PTB 204-001 Michigan City Road - Retaining Wall - STA. 396+60
Analysis Description	Exhibit e - Circular Failure Short Term (undrained) - Solider Pile
Drawn By	AA
Company	GSG Consultants, Inc.
Date	10/06/2023, 11:17:46 AM
File Name	Slope Stability Solider Pile (Slope Study).slmd

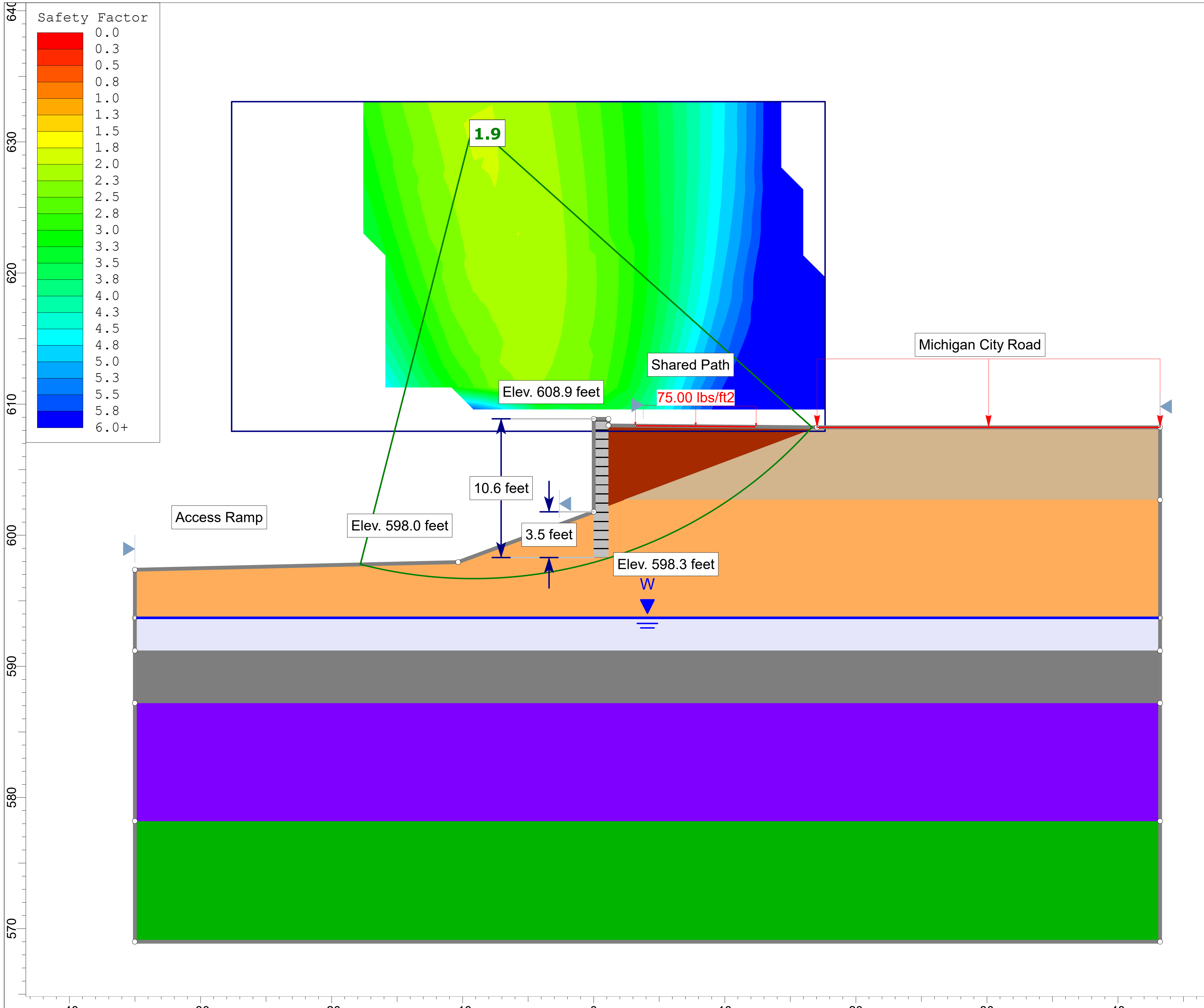


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Granular Fill		120	Mohr-Coulomb	0	28
New Engineered Clay Fill (Drained)		125	Mohr-Coulomb	100	28
Loose to Dense Brown Sand		125	Mohr-Coulomb	0	36
Loose to Medium Dense Gray Sand		126	Mohr-Coulomb	0	36
Loose to Medium Dense Silt		125	Mohr-Coulomb	0	35
Medium Stiff to Stiff Silty Clay (Drained)		137	Mohr-Coulomb	180	28
Stiff to Very Stiff Silty Clay (Drained)		138	Mohr-Coulomb	210	28
CIP Wall		150	Infinite strength		

GSG CONSULTANTS, INC.
735 Remington Road, Schaumburg, IL 60173
Tel: 630.994.2600, www.gsg-consultants.com

SLIDEINTERPRET 9.018

Project	PTB 204-001 Michigan City Road - Retaining Wall - STA. 396+60
Analysis Description	Exhibit f - Circular Failure Long Term (Drained) - Solider Pile
Drawn By	AA
Company	GSG Consultants, Inc.
Date	10/06/2023, 11:17:46 AM
File Name	Slope Stability Solider Pile (Slope Study).slmd

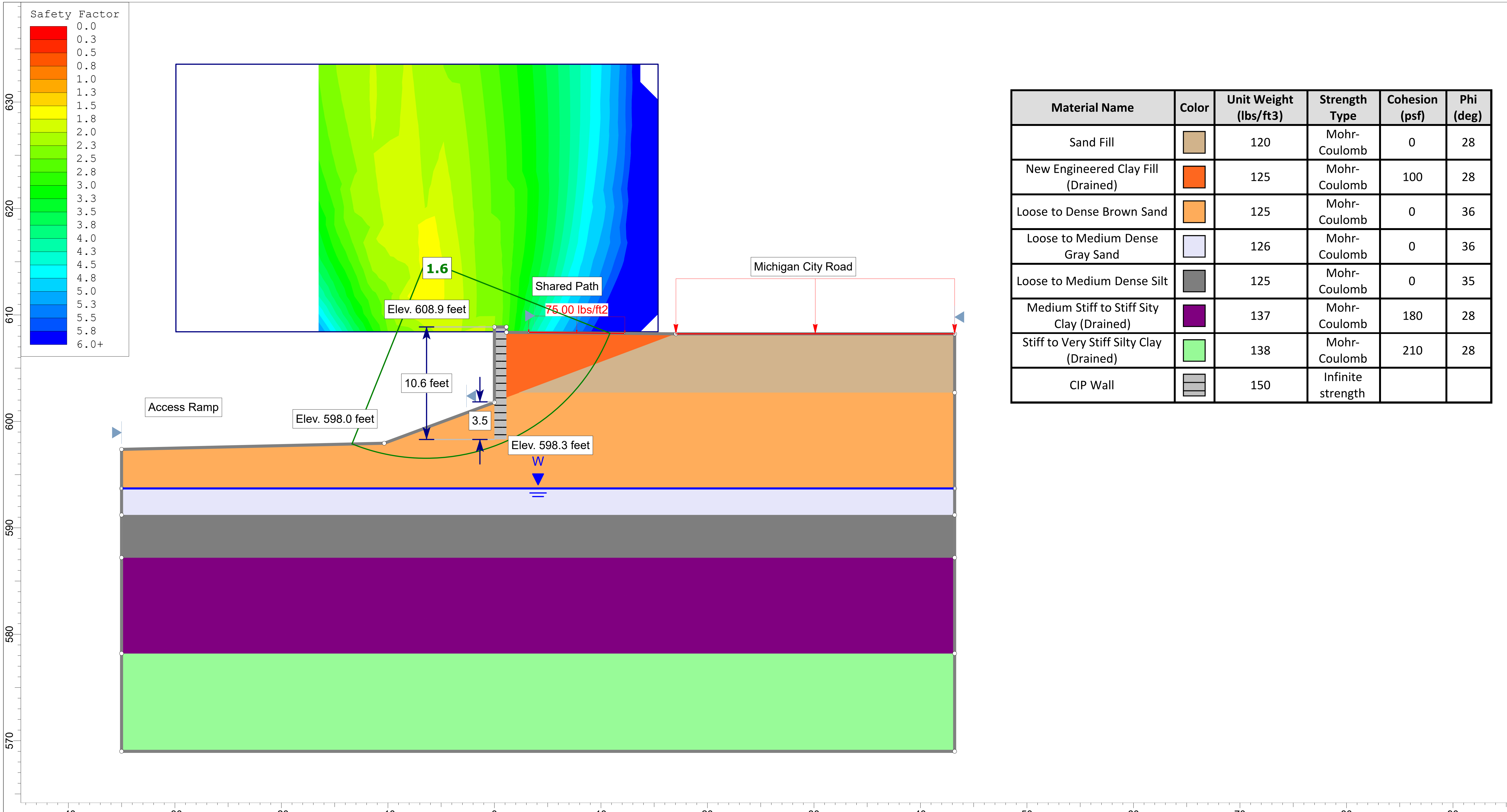


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Sand Fill		120	Mohr-Coulomb	0	28
New Engineered Clay Fill (Undrained)		125	Mohr-Coulomb	1000	0
Loose to Dense Brown Sand		125	Mohr-Coulomb	0	36
Loose to Medium Dense Gray Sand		126	Mohr-Coulomb	0	36
Loose to Medium Dense Silt		125	Mohr-Coulomb	0	35
Medium Stiff to Stiff Sity Clay (Undrained)		137	Mohr-Coulomb	1800	0
Stiff to Very Stiff Silty Clay (Undrained)		138	Mohr-Coulomb	2100	0
CIP Wall		150	Infinite strength		

GSG CONSULTANTS, INC.
735 Remington Road, Schaumburg, IL 60173
Tel: 630.994.2600, www.gsg-consultants.com

SLIDEINTERPRET 9.018

Project	PTB 204-001 Michigan City Road - Retaining Wall - STA. 395+75
Analysis Description	Exhibit g - Circular Failure Short Term (undrained) - Solider Pile
Drawn By	AA
Company	GSG Consultants, Inc.
Date	10/06/2023, 11:17:46 AM
File Name	Slope Stability Solider Pile (new dim).slmd



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Sand Fill		120	Mohr-Coulomb	0	28
New Engineered Clay Fill (Drained)		125	Mohr-Coulomb	100	28
Loose to Dense Brown Sand		125	Mohr-Coulomb	0	36
Loose to Medium Dense Gray Sand		126	Mohr-Coulomb	0	36
Loose to Medium Dense Silt		125	Mohr-Coulomb	0	35
Medium Stiff to Stiff Sity Clay (Drained)		137	Mohr-Coulomb	180	28
Stiff to Very Stiff Silty Clay (Drained)		138	Mohr-Coulomb	210	28
CIP Wall		150	Infinite strength		

GSG CONSULTANTS, INC.
735 Remington Road, Schaumburg, IL 60173
Tel: 630.994.2600, www.gsg-consultants.com

Project	PTB 204-001 Michigan City Road - Retaining Wall - STA. 395+75
Analysis Description	Exhibit h - Circular Failure Long Term (Drained) - Solider Pile
Drawn By	AA
Company	GSG Consultants, Inc.
Date	10/06/2023, 11:17:46 AM
File Name	Slope Stability Solider Pile (new dim).slmd

SLIDEINTERPRET 9.018

APPENDIX F

SOIL DESIGN PARAMETERS

Table F: Summary of Soil Parameters

Elevation (ft, NAVD/CCD)	Soil Description	In situ Unit Weight γ (pcf)	Undrained		Drained		Lateral Earth Pressure Long-term/Drained			Parameters for p-y Curve Method		
			Cohesion c (psf)	Friction Angle ϕ (°)	Cohesion c (psf)	Friction Angle ϕ (°)	Active Earth Pressure Coefficient (K_a)	Passive Earth Pressure Coefficient (K_p)	At-Rest Earth Pressure Coefficient (K_o)	p-y Curve Type in LPile	Coefficient of Lateral Subgrade Modulus* (k_{py}, pci)	Horizontal Strain Factor ε_{50}
	New Engineered Granular Fill	120	0	28	0	28	0.33	3.00	0.50	Sand	90	N/A
	New Engineered Clay Fill	125	1,000	0	100	28	0.41	2.46	0.58	Silty Clay w/o water	500	0.007
606.5-600.0	Fill: Dark Brown Sand	120	0	28	0	28	0.36	2.77	0.53	Sand	90	N/A
600.0-592.5	Light Brown Sand	125	0	36	0	36	0.26	3.85	0.41	Sand	60	N/A
592.5-590.0	Gray Sand	126	0	36	0	36	0.26	3.85	0.41	Sand	60	N/A
590.0-585.0	Gray Silty Loam	125	0	35	0	35	0.27	3.69	0.43	Sand	60	N/A
585.0-577.5	Gray Silty Clay	137	1,800	0	180	28	0.36	2.77	0.53	Silty Clay w/o Water	500	0.007
577.5-567.5	Gray Silty Clay	138	2,100	0	210	28	0.36	2.77	0.53	Silty Clay w/o Water	1,000	0.005

*The initial p-y modulus, E_{py} , varies linearly with depth. To obtain E_{py} use the equation $E_{py} = k_{py} * z$, where k_{py} is the coefficient of lateral modulus of subgrade reaction given in the table and z is the distance from the surface to the center point of the layer in inches.