STRUCTURE GEOTECHNICAL REPORT
BOX CULVERT
IL 176
MCHENRY COUNTY, ILLINOIS

Structure No. 056-0210

10/14/22

Prepared for:

Bowman Consulting Group Ltd.

1001 Warrenville Road, Ste. 110

Lisle, Illinois 60532

Prepared by:

INTERRA, INC.

600 Territorial Drive, Suite G, Bolingbrook, IL 60440

Phone: (630) 754-8700, Fax: (630) 754-8705

www.interraservices.com

INTERRA
Engineering • Inspection • Testing

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1.0 INTRODUCTION

Interra, Inc. (INTERRA) was tasked by Bowman Consulting Group Ltd. based in Lisle, Illinois to conduct subsurface soil investigation and prepare the Structural Geotechnical Report (SGR) for the improvement of culvert structure located under IL 176. The proposed improvement consists of removal headwall, wingwalls and approximately four feet of existing 6'x6' culvert at the south end. The culvert section will be replaced and extended by a few additional feet including new cantilever wingwalls and headwalls.

2.0 PROJECT SCOPE

INTERRA's scope of work included drilling one (1) structure geotechnical boring to a depth of 30 feet; performing associated laboratory tests on collected soil samples; preparation of Structure Geotechnical Report in accordance with IDOT Geotechnical Manual 2020.

3.0 SITE DESCRIPTION

The project section is located in Dorr Township, McHenry County and defined as Section 35 T44N, R7E Third Meridian. The subject area is located on IL 176, approximately 2900 feet west of Briarwood Dr. The surface elevation of the borehole is 903.25 feet. The invert elevation of the Box Culvert structure is at approximately 896.9 feet.

3.1 Mining Activity

From the Illinois State Geological Survey (ISGS, 2021), McHenry County is not identified as coal producing area. Therefore, no past coal mining activities may have taken place at the project site.

3.2 Seismic Considerations

USGS National Seismic Hazard Maps (AASHTO LRFD, Figure 3.10.2.1-1) indicate a Peak Ground Acceleration (PGA) of 3.5% of gravity, with a 7% probability of exceedance in 75 years. The project area has no active, major faults (Kolata, 2005).

4.0 FIELD INVESTIGATION

The locations of the borings are presented in the Borehole Location Plan in Appendix A. The Boreholes are as marked in the field by INTERRA.

Prior to drilling, the drilling sub-contractor Geocon Professional Services (GEOCON) contacted the local one-call utility clearance service (JULIE) to clear underground utilities. The borings were drilled with a truck mounted drill rig Diedrich D-50. INTERRA's engineer was present during the drilling to collect and log the soil samples. The borings were drilled, and samples were collected in general accordance with the guidelines in the IDOT Geotechnical Manual. Soil sampling was performed per AASHTO T-206, "Penetration Test and Split Barrel Sampling of Soils". Soil sampling was performed at 2.5-foot intervals up to a depth of 30 feet. The soil samples were taken in conjunction with the Standard Penetration Test where a driving resistance to a standard 2" split-spoon samples indicate relative density of granular materials and consistency of cohesive soils. Soil specimens from the borings were visually identified in accordance with the AASHTO and IDOT textural classification systems. Also, unconfined compressive strength tests were performed on cohesive samples using an Illinois modified RIMAC tester. Cohesive samples that could not be tested with a RIMAC tester were tested with a pocket penetrometer to estimate the unconfined compressive strength. Shelby tube samples were also collected at selected boring locations for performing laboratory tests. Water level readings were taken during drilling and immediately after drilling.

5.0 LABORATORY TESTING

All laboratory testing was performed in accordance with IDOT and/or AASHTO standard methods for testing. Moisture content tests (AASHTO T 265) were performed for all soil samples. Shelby Tube samples were tested for Unconfined Compressive Strength (ASTM

D 2166), Grainsize Analysis (AASHTO T 88) and Atterberg Limits (AASHTO T 89, 90). Laboratory test reports are presented in Appendix B.

Soil boring logs indicating the blow counts, moisture content and soil description have been prepared and included in Appendix A of this report.

6.0 SUBSURFACE CONDITIONS

Boring IL-176-BCB-01 encountered 5.0 inches of asphalt and 7.0 inches of stones at the surface. This was underlain by medium dense sandy loam up to 3.0 feet. Below this was medium stiff sandy clay loam up to 4.5 feet, followed by loose sand up to 5.5 feet. This was underlain by medium stiff sandy clay loam up to 8.0 feet. Very loose sand and gravel mix was encountered between 8.0 feet and 10.5 feet. This was underlain by loose silty loam up to 12.0 feet, followed by medium stiff sandy loam loam up to 14.0 feet. This was followed by medium stiff clay loam up to 15.5 feet. Loose rock aggregates were encountered between 15.5 feet and 18.0 feet. There was split spoon recovery between 18.0 feet and 20.5 feet. Layers of loose and medium dense sand and gravel mix was observed between 20.5 feet and 29.0 feet. This was underlain by stiff clay up to 30.0 feet. Boring was terminated at 30.0 feet.

For detailed stratification, please refer to boring logs presented as Appendix A.

Groundwater Information

Groundwater elevations were recorded during drilling and immediately after drilling at the boring location. Boring IL-176-BCB-01 encountered ground water at 18.5 feet depth during drilling and at 15.5 feet at end of drilling. Since the boreholes were backfilled immediately after drilling, the water levels reported may not represent the long-term groundwater levels. Changes in water levels should be expected due to seasonal variations and precipitation.

7.0 ANALYSIS AND RECOMMENDATIONS

The following recommendations are developed based on the field investigation and laboratory testing, project information provided to INTERRA, IDOT Culvert Manual, Standard Specifications and the AASHTO LRFD Bridge Design Specifications, 9th Edition, 2020.

It is our understanding that the headwall, wingwalls and approximately a four-foot section on the south end of the existing box culvert will be removed and replaced with new culvert section longer by a few additional feet, a new head wall and new horizontal cantilever wingwalls. We also understand that the replacement culvert will be the minimum length of 6 feet or half the length of the wingwalls.

BEARING CAPACITY AND SETTLEMENT

Design loads for the proposed construction were not provided. However, for analyses purposes, it is estimated that the approximate bearing pressure applied to the foundation soils will be less 1500 psf at an approximate depth of 8 feet below the existing roadway grade. Foundation soils at this elevation consist of medium stiff clay loam and very loose to loose sand and gravel. We recommend a one foot undercut. Unsuitable soil shall be replaced with rockfill in accordance with the following paragraph. Foundation soils can be designed for a factored bearing resistance of 2000psf, which includes an LRFD Resistance Factor of 0.45. Although the roadway grade will not be changing, some additional fill is anticipated on the replacement sections. Settlements are expected to be no greater than one (1) inch due to minimal additional fill.

During construction, if additional unsuitable soils are encountered, the engineer should be contacted to determine the lateral and vertical extent of undercuts needed. The unsuitable soils will need to be removed and replaced with suitable material. We recommend undercutting unsuitable soils and replacing with Rockfill. A woven geotextile fabric should be used below the aggregate improvement for ground stabilization (IDOT Section 1080.02). The aggregate shall be capped with six inches of CA7 and satisfy the Standard Specifications unless otherwise indicated in the Special Provisions. If the

foundation soils become unstable due to construction equipment loadings during excavation or construction, a working platform may be needed. The need for such platform is dependent on the type, thickness and strength of the soils encountered, the method of water diversion selected by the Contractor, precipitation, construction sequence, and the time of the year the box culvert is constructed. The Engineer should make the determination that a working platform is required during excavation based on the field conditions.

WINGWALLS

Plans indicate that existing wingwalls are horizontal. IDOT Culvert Manual requires that a portion of the barrel equal to the minimum of half the wingwall length or six (6) feet shall be poured monolithically with the wingwalls. Horizontal cantilever wingwalls are proposed.

The Wing walls at the box culvert should be designed for the lateral earth pressures and lateral pressures from live loads. In accordance with the culvert manual, Table 4.1.1.2-1, the earth pressure in horizontal (P_H) is estimated to be 65 psf for a horizontal cantilever wingwall. Live load surcharge from traffic and other surcharges can be estimated using a surcharge equivalent to 2 feet of soil for wingwalls. IDOT Standard Specifications and details should be followed for drains and limits of free draining material behind the wall.

STABILITY ANALYSES

Global slope stability analyses were conducted for the critical cross-section assuming wall height of 15 feet and a 3H:1V backfill. The LRFD resistance factor considered is 0.65, which is equivalent to slope stability factor of safety of 1.54. Slope stability analyses were conducted using SLIDE V7.0. Analyses indicated that the global slope stability factor of safety exceeded the minimum required value of 1.54 for both short and long-term loading conditions. Appendix C contains the results of the slope stability analyses.

CHANNEL PROTECTION

Channel protection at culvert outlets can be achieved by providing a riprapped transition or apron from the culvert outlet to the natural channel. The riprap should have bedding

and/or filter fabric under it and should be of sufficient size and depth for the anticipated flow. A length of protection of three times the anticipated velocity in feet per second is commonly used as a rule of thumb.

SCOUR

As per All Bridge Designers Memo 14.2, design scour elevations for box culverts are no longer needed.

8.0 CONSTRUCTION CONSIDERATIONS

The contractor can consider temporary ditches, sumps, granular drainage blankets and other methods to control surface water infiltration and ground water and provide a dry condition for construction.

The proposed construction will be in stages and Temporary Soil Retention System (TSRS) may be required to facilitate the removal of the existing wingwalls and construction of the new headwall and wingwalls. It is anticipated that temporary shoring will be required during the stage construction. Temporary shoring is feasible using simple cantilevered temporary sheet piling. Table 1 lists suggested lateral earth pressure and soil resistance parameters. All excavations must be performed in accordance with local and federal regulations.

Table 1 - Recommended Soil Parameters for Temporary Soil Retention Systems

Elevation (Depth below Proposed roadway surface) Ref boring BCB-01	**Soil Type**	**Saturated Unit Weight (pcf)**	**Shear Strength (psf)**		**Friction Angle (deg)**		**Coulomb Active Earth Pr. Coeff, Ka**	**At-Rest Earth Pr. Coeff, K_0**	**Passive Earth Pr. Coeff., Kp**	**Soil Modulus, k (pci)**	**Epsilon 50 Strain**
			Undrained	**Drained**	**Undrained**	**Drained**					
0'-5'	Loose Sandy Loam	115	-	-	-	25	0.36	0.58	2.46	25	-

5’-7’	Medium Stiff Cohesive Soil	120	700	50	-	26	0.36	0.56	2.56	100	0.009
7’-30’	Loose to Med. Dense granular soils	115	-	-	-	25	0.36	0.58	2.46	20	-

9.0 CLOSURE

The analysis and recommendations submitted in this report are based upon the data obtained from one (1) soil boring performed at the location indicated on the Borehole Location Plan, project information provided to INTERRA and from any other information discussed in this report. This report does not reflect any variations that may occur between these boreholes. In performing subsurface explorations, specific information is obtained at specific locations at specific times. It is a well-known fact that variations in soil and rock conditions exist on most sites between borehole locations. Also, groundwater levels vary from time to time. The nature and extent of variations may not become evident until the course of construction. If project characteristics change or if variations in the subsurface conditions appear evident, it will be necessary for a re-evaluation of the recommendations of this report.

We appreciate the opportunity to be of service to you. Should you need additional information or clarifications, please call us at (630) 754-8700.

Yours truly,

INTERRA, INC.

Ashok Guntaka, EI
Project Engineer

Reshma Chirakkara, Ph.D.
Staff Engineer

Sanjeev Bandi, Ph.D., PE
Project Manager

LICENSED PROFESSIONAL ENGINEER
SANJEEVREDDY
BANDI
062-051187
OF ILLINOIS
11/30/23

Sudhakar "Rao" Doppalapudi, PE
QC/QA Reviewer

REFERENCES

AASHTO 2020, LRFD Bridge Design Specifications, 9th Edition 2020, American Association of State Highway and Transportation Officials, Washington, DC.

IDOT 2020, Geotechnical Manual, Illinois Department of Transportation.

IDOT 2016, Culvert Manual, Illinois Department of Transportation.

IDOT 2016, Standard Specifications for Road and Bridge Construction. Illinois Department of Transportation.

IDOT 2012, Bridge Manual, Bureau of Bridges and Structures, Illinois Department of Transportation.

Kolata, D. R., 2005, Bedrock Geology of Illinois, Illinois Map 14, Illinois State Geological Survey.

U.S.G.S. 2014, National Seismic Hazard Maps.
http://earthquake.usgs.gov/research/hazmaps/

Coduto, Donald P., 1994, Foundation Design, Prentice Hall, Inc.

Appendix A

Site Location Map

Borehole Location Plan and Profiles

Soil Boring Logs

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SITE LOCATION MAP
IL 176 BOX CULVERT
STRUCTURE NO: 056-0210
MCHENRY COUNTY, ILLINOIS
INTERRA Project No. 9244

BOREHOLE LOCATION PLAN
IL 176 BOX CULVERT
STRUCTURE NO: 056-0210
MCHENRY COUNTY, ILLINOIS
INTERRA Project No. 9244

BOREHOLE LOCATION PLAN
IL 176 BOX CULVERT
STRUCTURE NO: 056-0210
MCHENRY COUNTY, ILLINOIS
INTERRA Project No. 9244

Interra, Inc.
600 Territorial Drive, Suite G
Bolingbrook, IL 60440
www.interraservices.com

SOIL BORING LOG

Date 8/24/22

ROUTE IL-176 **DESCRIPTION** IL-176 Box Culvert **LOGGED BY** A. Boland

SECTION _____ **LOCATION** 2033717.368,970089.592

COUNTY Lake **DRILLING METHOD** Hollow Stem Auger **HAMMER TYPE** Automatic

STRUCT. NO. 056-0210
Station _____

BORING NO. IL-176-BCB-01
Station _____
Offset _____
Ground Surface Elev. 903.25 ft

Surface Water Elev. _____ ft
Stream Bed Elev. _____ ft

Groundwater Elev.:
First Encounter 884.7 ft ▼
Upon Completion 887.7 ft ▽
After _____ **Hrs.** Not Taken ft

	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
ASPHALT (5") 902.83				
STONE (7") 902.25				
Medium dense brown, SANDY LOAM and gravel		3		
		5		11.3
		5		
900.25				
Medium stiff brown SANDY CLAY LOAM, trace gravel		1		
		2		13.6
898.75				
Loose brown, SAND, trace gravel	-5	3	0.5 P	
897.75				
Medium stiff, brown, SANDY CLAY LOAM, some gravel		2		
		1		14.3
		1	0.6 B	
895.25				
Very loose, brown SAND and GRAVEL, moist		2		
		2		9.7
	-10	1		
892.75				
Loose, gray SILTY LOAM, some sand, some gravel, moist		3		
891.25				
		2		11.7
Medium stiff, gray SANDY LOAM, little gravel, moist		2		
Shelby tube taken (offset) @ 12'-14'. LL=16%, PI=5%,Qu=0.68 tsf,moisture=11.3% 889.25		2		
Medium stiff, gray CLAY LOAM, little gravel		2		10.0
	-15	3	0.6 B	
887.75 ▽				
Loose, ROCK AGGREGATE		6		
		3		
		4		
885.25				
NO RECOVERY ▼				
	-20			

	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
NO RECOVERY *(continued)* 882.75				
Gray SAND and GRAVEL, moist				
Loose		3		
		3		12.5
		4		
Medium dense		15		
		14		6.5
	-25	8		
Loose		10		
		4		11.5
		5		
		10		
Medium dense 874.25		8		13.4
Stiff gray CLAY, moist. Moisture = 10.9% 873.25		6		
	-30			
End of boring at 30'				
	-35			
	-40			

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)

Appendix B

Laboratory Test Reports

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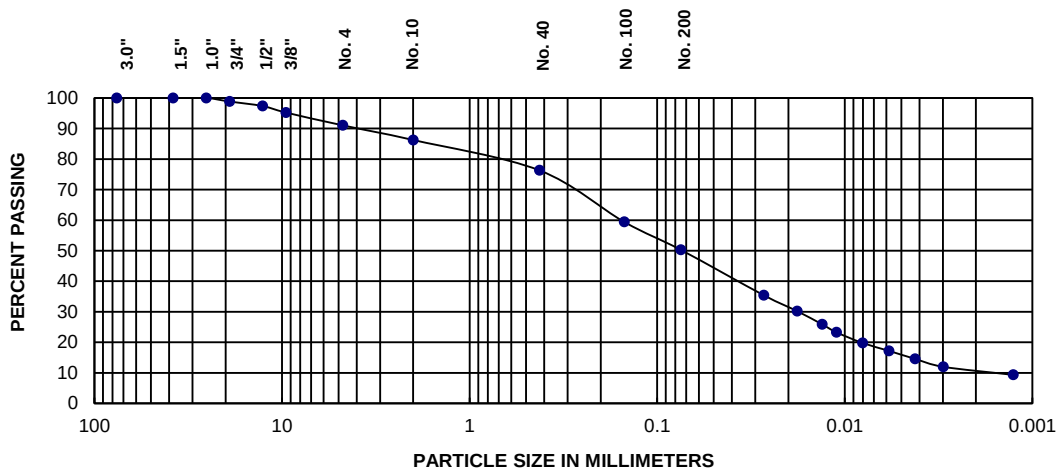
GRAIN SIZE ANALYSIS
AASHTO T 88

Project	Geotechnical Investigation, Box Culvert at IL 173 and IL 176, PTB 195-016-WO 24, Lake County, IL						
Client	Bowman Consulting, 1001 Warrenville Road, Ste. 110, Lisle, IL 60532						
File No.	9244	**Sample #**	IL176 BCB 01-ST-13	**Date Tested**	9/1/2022	**Tested by**	BKP
						Qc by	AB

Date Sample Received:	8/25/2022
Sample Location	12' - 14'
Sample Description	Gray sandy loam, little gravel



			Fines	
% + 3"	**% Gravel**	**% Sand**	**% Silt**	**% Clay**
0.0	13.7	36.0	39.4	10.9

For coarse-grained soils with <12% Fines	D60(mm)	D30(mm)	D10(mm)	Cu	Cc

Sieve Size	**Percent Passing**
3.0"	100.0
1.5"	100.0
1.0"	100.0
3/4"	98.9
1/2"	97.4
3/8"	95.2
No. 4	91.1
No. 10	86.3
No. 40	76.3
No. 100	59.4
No. 200	50.3

Liquid Limit, L_L	**Plastic Limit, PL**	**Plasticity Index, PI**
16	11	5

AASHTO Classification:	A-4(0)
IDH Classification:	Sandy Loam

Remarks:	

Test ID	69581

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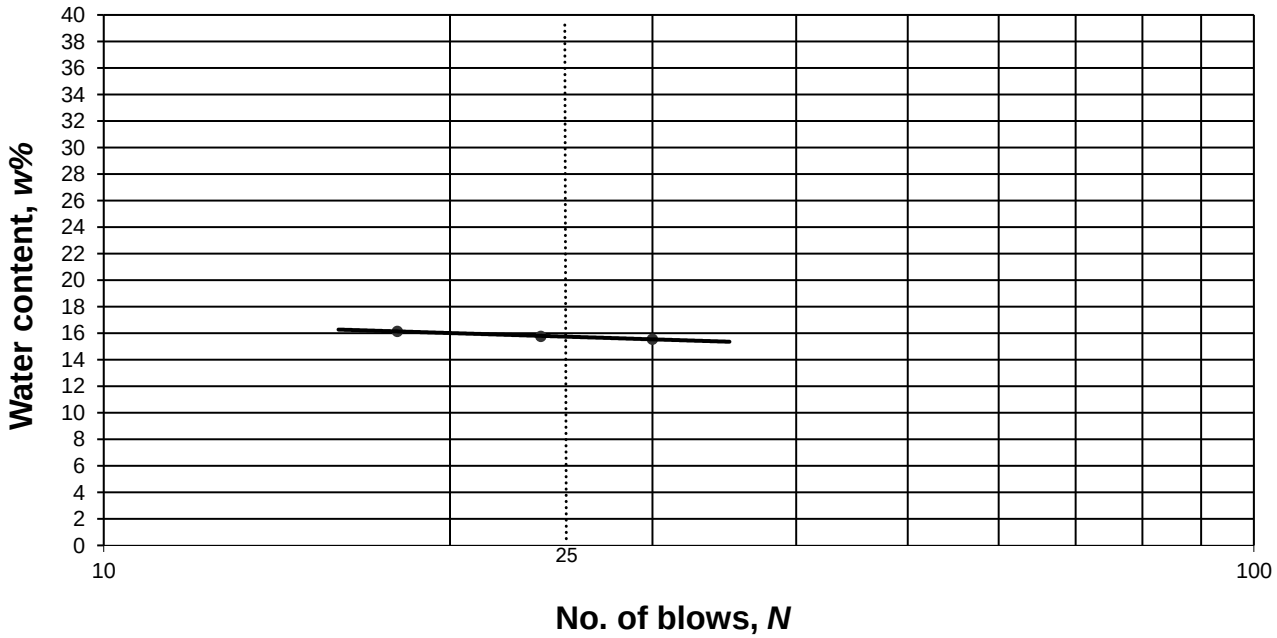
Atterberg Limits

AAASHTO T 89,90

Project	Geotechnical Investigation, Box Culvert at IL 173 and IL 176, PTB 195-016-WO 24, Lake County, IL						
Client	Bowman Consulting, 1001 Warrenville Road, Ste. 110, Lisle, IL 60532						
File No.	9244	**Sample #**	IL176 BCB 01-ST-13	**Date Tested**	9/5/2022	**Tested By**	DG
						Qc By	AB

Date Sample Recd.	8/25/2022
Sample Location	12' - 14'
Sample Description	Gray sandy loam, little gravel

LIQUID LIMIT DETERMINATION



Results					
Liquid Limit, LL	**16**	**Plastic Limit, PL**	**11**	**Plasticity Index, PI**	**5**

Remarks

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Moisture Content
AASHTO T265

Project	Geotechnical Investigation, Box Culvert at IL 173 and IL 176, PTB 195-016-WO 24, Lake County, IL						
Client	Bowman Consulting, 1001 Warrenville Road, Ste. 110, Lisle, IL 60532						
File No.	9244	**Sample #**	IL176 BCB 01-ST-13	**Date Tested**	8/30/2022	**Tested By**	AB
						Qc By	RC

Date Sample Received	8/25/2022
Sample Location	12' - 14'
Sample Description	Gray sandy loam, little gravel

Can Number :	69AC	
Can Weight :	29.96	gm
Can + Wet Sample Weight :	157.27	gm
Can + Dry Sample Weight :	144.30	gm
Moisture Content :	**11.34**	%

Remarks

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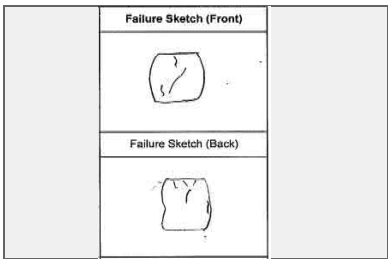
UNCONFINED COMPRESSIVE STRENGTH (ASTM D 2166)

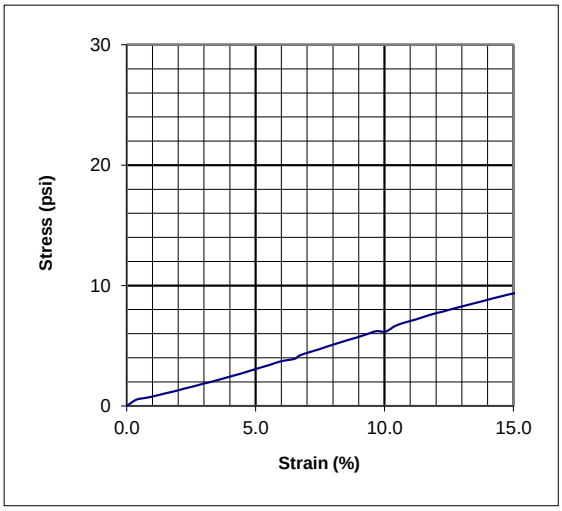
Project	Geotechnical Investigation, Box Culvert at IL 173 and IL 176, PTB 195-016-WO 24, Lake County, IL						
Client	Bowman Consulting, 1001 Warrenville Road, Ste. 110, Lisle, IL 60532						
File No.	9244	**Sample No.**	IL176 BCB 01-ST-13	**Date Tested**	8/30/22	**Tested By**	AB
						QC By	RC

Date Sample Received	8/25/22
Description of Soil	Gray sandy loam, little gravel
Location	12' - 14'

Type of Sample	ST	
Average Height =	13.65	cm
Average Diameter =	6.89	cm
Height/Diameter Ratio =	1.98	
Wet Sample Weight=	1216.62	g
Wet Density =	2.39	g/cc
Moisture Content =	10.6	%
Dry Density =	2.16	g/cc
Strain Rate =	1.12	%/min



Failure Image

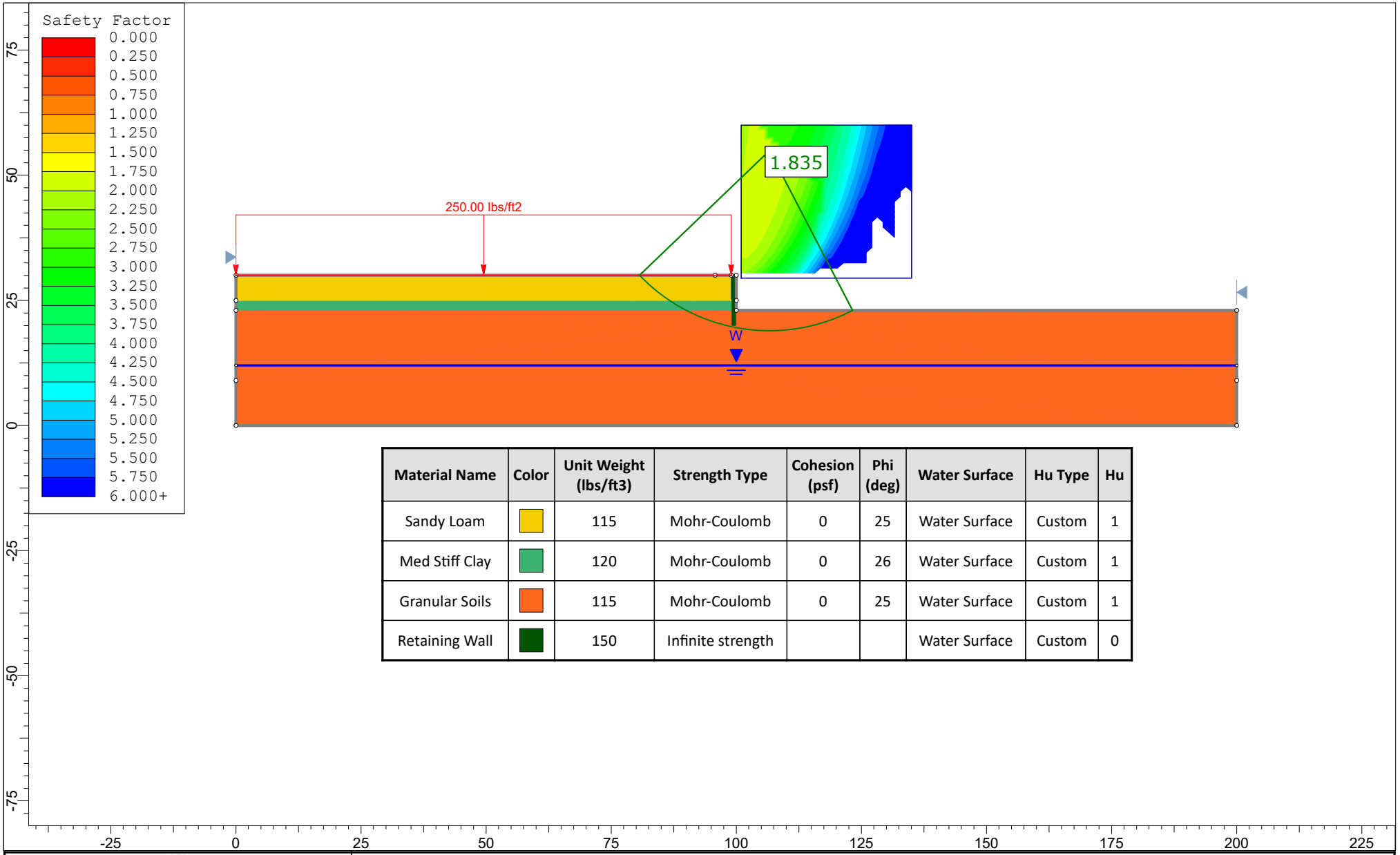


Unconfined Compressive Strength =	9.46 **0.68**	psi **tsf**
Shear Strength =	4.73 0.34	psi tsf
Strain at Failure =	15.3	%

Remarks:

Appendix C

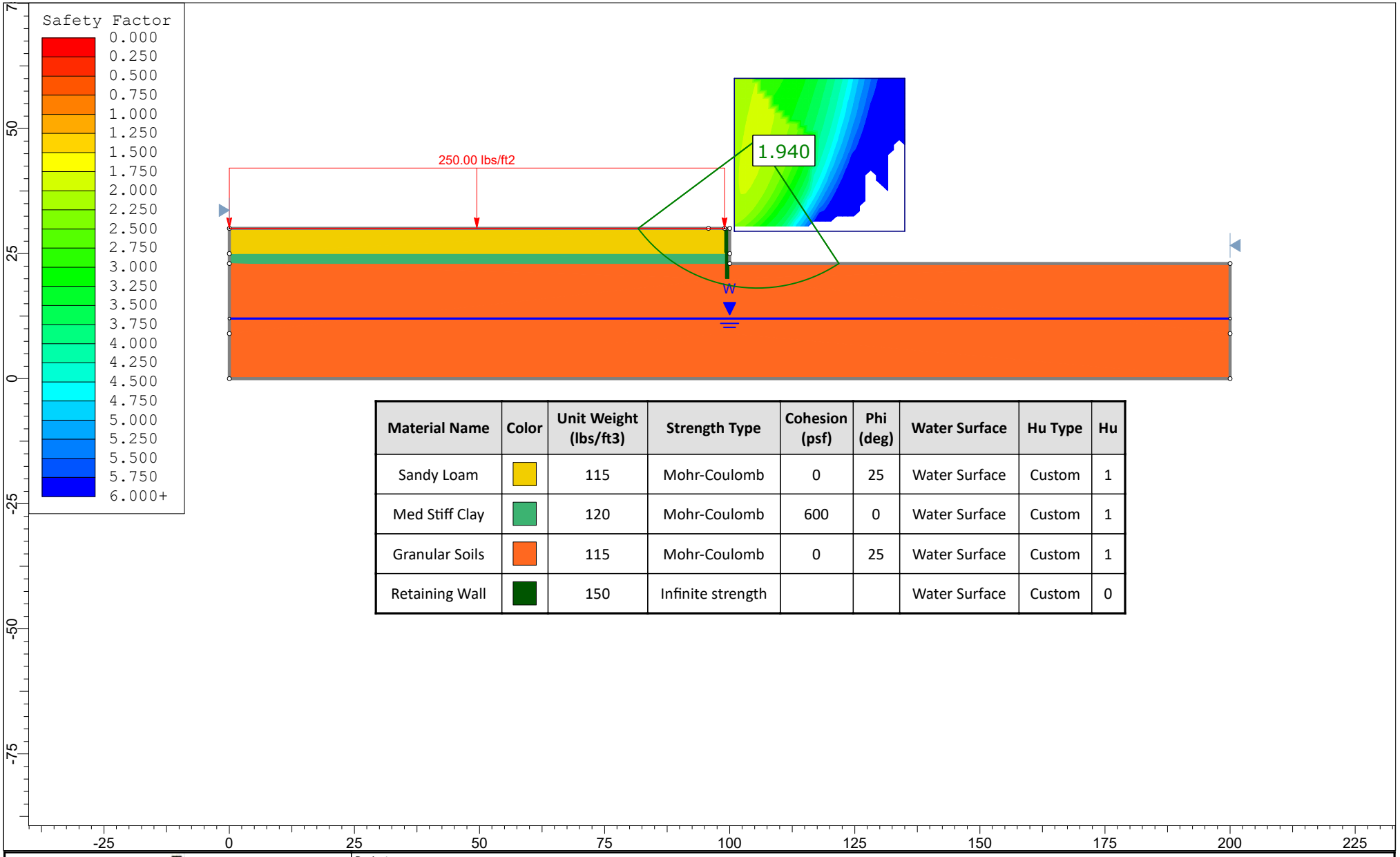
Slope Stability Analyses



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Sandy Loam		115	Mohr-Coulomb	0	25	Water Surface	Custom	1
Med Stiff Clay		120	Mohr-Coulomb	0	26	Water Surface	Custom	1
Granular Soils		115	Mohr-Coulomb	0	25	Water Surface	Custom	1
Retaining Wall		150	Infinite strength			Water Surface	Custom	0

SLIDEINTERPRET 7.038

Project	Box Culvert Wing Wall-IL 176		
Analysis Description	Global Stability Analysis-Long Term		
Drawn By		Scale 1:318	Company INTERRA, INC.
Date	10/12/22		Retaining Wall-Long-Term Stability.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Sandy Loam		115	Mohr-Coulomb	0	25	Water Surface	Custom	1
Med Stiff Clay		120	Mohr-Coulomb	600	0	Water Surface	Custom	1
Granular Soils		115	Mohr-Coulomb	0	25	Water Surface	Custom	1
Retaining Wall		150	Infinite strength			Water Surface	Custom	0

SLIDEINTERPRET 7.038

Project	Box Culvert Wing Wall-IL 176		
Analysis Description	Global Stability Analysis-Short Term		
Drawn By		Scale 1:318	Company INTERRA, INC.
Date	10/12/22		Retaining Wall-Short-Term Stability.slim