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Technical Memo
Proposed Temporary Sheet Pile Wall
IDOT PTB 186/001 Montrose Avenue over I-90/94

This design memorandum presents preliminary recommendations for the proposed temporary sheet pile wall for the above referenced project. GSG Consultants, Inc. (GSG) completed a geotechnical investigation for the installation of temporary sheet pile walls for excavation activities at Montrose Bridge over I-90/94 in Chicago, 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 installation of temporary sheet piling for the project.

1. Site Conditions and Proposed Project Information

Montrose bridge (S.N. 016-0852) was built in 1957 and repaired in 1997. The bridge is a three-span structure with the east span over eastbound I-90/I-94; the middle span over westbound I-94 and the CTA-Montrose Station; and the west span over westbound I-90/I-94. The existing structure consists of a three simple-span, post-tensioned cast-in-place Tee Beam. The substructure consists of full height closed abutments, wingwalls, and column piers all founded on spread footings. The surface of the pavement at the bridge is relatively flat at about an elevation of 606 to 609 feet. It is our understanding that the existing bridge superstructure will be replaced.

Based on the preliminary design information provided by Ciorba (client), temporary sheet pile retaining walls will be required during construction for the new bridge over I-90/94. It is anticipated that these walls would have exposed heights of approximately 9 to 10 feet to provide enough vertical clearance for the construction. Plans are not currently available on the sheet pile design; Table 1 summarizes the assumed/approximate sheet pile wall information discussed in this report.

Table 1 – Wall information Summary

Wall Location	Maximum Exposed Wall Height (ft)	Back Slope / Front Slope
West Abutment	9.5	Level
East Abutment	10.5	Level

2. Subsurface Exploration Program

The proposed locations and depths of the soil borings were proposed by Ciorba. Prior to performing the field activities, GSG secured a permit from the Chicago Department of Transportation (CDOT) and contacted DIGGER to locate underground utilities within the project area. GSG adjusted the soil boring locations based on CDOT requirements, field conditions, the presence of utilities along the road, and accessibility for the drilling equipment. The subsurface exploration was conducted on March 19 and 21, 2019 and included advancing two (2) standard penetration test (SPT) borings near the locations of the temporary proposed walls. The borings were drilled to depths of 40.0 feet below existing grade. The as-drilled locations of the soil borings are shown on the **Appendix A - Boring Location Plan**. **Table 2** presents the summary of the borings completed.

Table 2 – Summary of Subsurface Exploration Borings

Soil Boring	Location	Latitude	Longitude	Depth (feet)	Existing Ground Elevation (feet)
B-1	East side of Montrose Avenue Bridge	41.960821	-87.744021	40.0	607.1
B-2	West side of Montrose Avenue Bridge	41.960863	-87.741893	40.0	609.6

The soil borings were drilled using a Mobile B-57 truck mounted drill rig using 3¼-inch I.D. hollow stem augers and an auto 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 termination depth. 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 concrete.

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.

3. 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 of the proposed retaining walls. Laboratory tests consisting of Moisture Contents (ASTM D2216) were performed on representative soil samples.

Based on the laboratory test results, the soils encountered were classified according to the Unified Soil Classification System (USCS). The results of the laboratory testing program are shown along with the field test results in **Appendix B, Soil Boring Logs.**

4. Subsurface Conditions

This section provides a brief description of the soils encountered in the borings performed. 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.

The soil boring logs provide specific conditions encountered at each boring location. The soil boring logs 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.

Boring B-1 noted 3.5 inches of asphalt over 11.5 inches of concrete with rebar at the surface (approximately elevation at 607 feet) underlain by sand with gravel fill soils to a depth of 3.5 feet below existing grade. Beneath the fill, very stiff brown and gray silty clay was noted to a depth of 6 feet below existing grade. Following this depth, stiff to very stiff gray silty clay was encountered to the boring termination depth of 40 feet. Cobbles were encountered at a depth of 13.5 feet below existing grade. The brown and gray silty clay had unconfined compressive strength of 4.0 tsf; the gray silty clay had unconfined compressive strengths ranging from 1.7 tsf to 4.0 tsf.

Boring B-2 noted 3 inches of asphalt over 9 inches of concrete at the surface (approximately elevation at 609.6 feet). Beneath the pavement, very stiff to hard brown and gray silty clay was noted to a depth of 9 feet followed by stiff to hard gray silty clay to the boring termination depth of 40 feet below existing grade. Cobbles were encountered at a depth of 18.5 feet below existing grade. The brown and gray silty clay had unconfined compressive strengths ranging from 3.0 tsf to 4.4 tsf; the gray silty clay had unconfined compressive strengths ranging from 2.0 tsf to 4.2 tsf.

5. 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. Groundwater was not encountered in the borings while drilling, upon completion or after drilling was completed. The boreholes were not left open after completion, and no 24-hour readings were collected due to safety reasons.

Based on the color change from brown to gray, it is anticipated that the long-term groundwater level is near elevation 600 to 601 feet. However, it should be noted that fluctuations in groundwater level may occur due to variations in rainfall, other climatic conditions, Lake Michigan water levels or other factors not evident at the time measurements were made and reported herein.

6. Derivation of Soil Parameters for Design

GSG determined the geotechnical parameters to be used for the project design based on the results of field and laboratory test data on individual boring logs as well as our experience. Unit weights, friction angles and shear strength parameters were estimated using standard penetration test (SPT) results for the fill and cohesion less soils and in-situ and laboratory test results for cohesive soils. The SPT values were corrected for hammer efficiency and overburden weight. The hammer efficiency correction factor considers the use of a safety hammer/rope/cat-head system, generally estimated to be 60% efficient. Thus, correlations should be based upon what is currently termed as N_{60} data. GSG used a truck mounted Mobile B-57 drill rig for completing the field subsurface exploration at this site. The efficiency of the automatic hammers for the drill rig was measured to be approximately 98%, based on GSG's most recent calibrations records. The correction for hammer efficiency is a direct ratio of relative efficiencies. The following equations should be used in calculating the corrected blow counts for the purposes of design and analysis:

$$N_{60} = N_{Field} * (98/60) \text{ for Mobile B-57 drill rig}$$

Where the N_{Field} value is the field recorded blow counts during drilling activities.

Table 3 presents generalized soil parameters to be used for design based on the laboratory and in-situ testing data:

Table 3 – Summary of On-site Soil Parameters

Depth (Elevation, feet)	Soil Description	In situ Unit Weight γ (pcf)	Undrained		Drained	
			Cohesion c (psf)	Friction Angle ϕ (Degrees)	Cohesion c (psf)	Friction Angle ϕ (Degrees)
1.0 – 8.5 (608.0 – 600.5)	Brown and Gray Stiff to Hard Silty Clay	138	3,500	0	125	28
8.5 – 41.0 (592.0 – 579.0)	Gray Stiff to Hard Silty Clay	134	2,500	0	100	28
3.0 – 5.0 (606.0 – 604.0) (B-1 only)	Fill Brown Sand	132	0	26	0	26

7. Geotechnical Recommendations

This section provides recommendation regarding design parameters for the proposed sheet pile design. The recommendations were developed based on the project information provided by the Ciorba and the results of the site investigation. If there are any significant changes to the project characteristics or if significantly different subsurface conditions are encountered during construction, GSG should be consulted so that the recommendations of this report can be reviewed. GSG understands that the proposed temporary earth retention system will be a sheet pile wall. Below is a general discussion of the wall design requirements and required design parameters.

Sheet Pile Wall Design

Sheet pile walls are typically used in cut areas when continuous support must be provided to maintain existing structures or other adjacent facilities. To provide lateral resistance against the retained soil, the walls can be designed to act as a cantilever or can use tie backs behind the wall. The installation of sheet pile walls requires the use of specialty equipment to drive the piles into the ground. The walls maintain the existing site conditions with minimal disturbance to existing structures and can be installed relatively quickly. Due to the presence of very stiff clays below elevation 586 feet (proposed grade in front of the wall) and the occasional presence of cobbles at various elevations, we recommend using a heavier pile section with a minimum thickness of 0.4 inch to alleviate any damage to the pile section during driving. Grade 50 steel should be used for the sheet pile. The interlocks could be partially clogged during driving and after installation due to fine soil particle migration. The steel sheet piles may be subject to potentially corrosion. Corrosion rates are typically a function of temperature, soil pH, access to oxygen, and chemistry of the environment surrounding the pile. The walls are intended to be temporary, but if the wall is to remain in place as a long-term wall, corrosion deterioration should be evaluated on the sheet pile wall design.

GSG does not anticipate any constructability issues based on the soil condition while driving these sheet piles, however, if an alternate system is considered then an anchored wall system may be considered. Different anchor systems such as grouted tiebacks, deadman anchor, or waler beams may be considered. The anchor system will transmit all loads from the soil through the retaining walls to the anchor and will align and brace the walls in position.

Lateral Earth Pressures and Loading

The wall 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. Sheet 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 (K_a), and the passive earth pressure coefficient (K_p) were determined in accordance with AASHTO Section 3.11.5.3 and 3.11.5.4, respectively.

The design should include a structural evaluation of the sheet pile section to meet applied shear and moment, and an evaluation of overturning to determine embedment depth and other design requirements. The simplified earth pressure distributions shown in the AASHTO Standard Specifications for Highway Bridges could be used for the wall design. **Table 4** 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 sheet pile wall should be ignored for the upper 3.5 feet due to excavation activities and frost-heave condition. Based on OSHA (Occupational Safety and Health Administration) technical manual, soil is classified, and soil type is listed in **Table 4 .**

Table 4 - Geotechnical Lateral Design Parameters

Depth (Elevation) (feet)	Soil Description	Active Earth Pressure Coefficient (K_a)	Passive Earth Pressure Coefficient (K_p)	At Rest Earth Pressure Coefficient (K_o)	Lateral Modulus of Subgrade Reaction (pci)	Soil Strain (ε_{50})	Adhesion (C_a) psf	Friction Angle between Steel and Soils (Tan δ)	OSHA Soil Type
1.0 – 8.5 (608.0 – 600.5)	Brown and Gray Stiff to Hard Silty Clay	0.36	2.77	0.53	1,750	0.005	950	NA	Type A
8.5 – 41.0 (592.0 – 579.0)	Gray Stiff to Hard Silty Clay	0.36	2.77	0.53	1,250	0.005	950	NA	Type A
3.0 – 5.0 (606.0 – 604.0) (B-1 only)	Fill Brown Sand	0.39	2.56	0.56	90	NA	NA	17 (0.30)	Type C

In accordance with OSHA Regulation 29 CFR 1926 Subpart P Appendix B, the maximum allowable slopes for excavations less than 20 feet should be completed per the OSHA Excavation Slopes shown in **Table 5**. Excavations made in layered soil systems shall use the maximum allowable slope for each layer as prescribed in the OSHA Regulation. Excavations greater than 20 feet deep should be designed by a registered professional engineer; any shoring or bracing systems should be designed by a licensed structural engineer.

Table 5 – OSHA Excavation Slopes

Soil or Rock Type	Maximum Allowable Slope (H:V) for less than 20 feet
Stable Rock	Vertical (90°)
Type A	¾:1 (53 °)
Type B	1:1 (45 °)
Type C	1 ½:1 (34 °)

Traffic and other surcharge loads should be included in the sheet pile wall design. A live load surcharge of 250 psf (or the equivalent weight of 2 feet soil overburden) should be applied where vehicular load is expected to act on the surface of the backfill. Heavy 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.

Excavation Base Stability

In open-cuts, it is necessary to consider the possibility of the base of the excavation failure by heaving, due to the removal of the weight of excavated soil. Heaving typically occurs in very soft or soft fat clays, when the excavation depth is sufficiently deep enough to cause the surrounding soil to displace vertically due to a failure of the soil beneath the excavation bottom, with a corresponding upward movement of the soils in the bottom of the excavation. Neither of these soil types were encountered in the borings. In fat and lean clays, heave normally does not occur unless the ratio of Critical Height to Depth of Cut approaches one. The sheet pile wall designer should check to make sure the sheet pile is sufficiently embedded in the stiffer clay soils to avoid heaving.

8. Construction Considerations

This section provides general consideration during construction activities at the site. Site specific information should be utilized based on site survey condition and construction phasing of the project.

Existing Utilities

Based on the DIGGER locate of utilities in the area of the borings, there are significant utilities in this area. Before proceeding with construction, any existing underground utility lines that will interfere with construction should be completely rerouted or removed from beneath the proposed construction areas. 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 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.

General Excavations

The contractor will be responsible to provide 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 for all excavation activities.

Groundwater Management

Based on the soil boring logs, the long-term water table is about 6 to 9 feet below the existing ground surface; however, groundwater was not encountered during the drilling operations. Based on the cohesive soils encountered throughout the borings, it is not anticipated that any significant groundwater issues will be present at the site. To avoid potential ground water issues during construction, GSG recommends that the sheet piles incorporate interlocking edges and extend into the clay soils, to act as a cutoff wall to prevent ground water from entering the site. Some water may still seep through the interlocks of the steel sheeting, but this could be removed by normal sump pump operations. Even then well points may be required to dewater the excavation area and the contractor should provide a dewatering plan detailing how groundwater will be controlled and prevent water infiltration into the excavation/construction site.

Should you have any questions or require additional information, please call us at 312-733-6262.

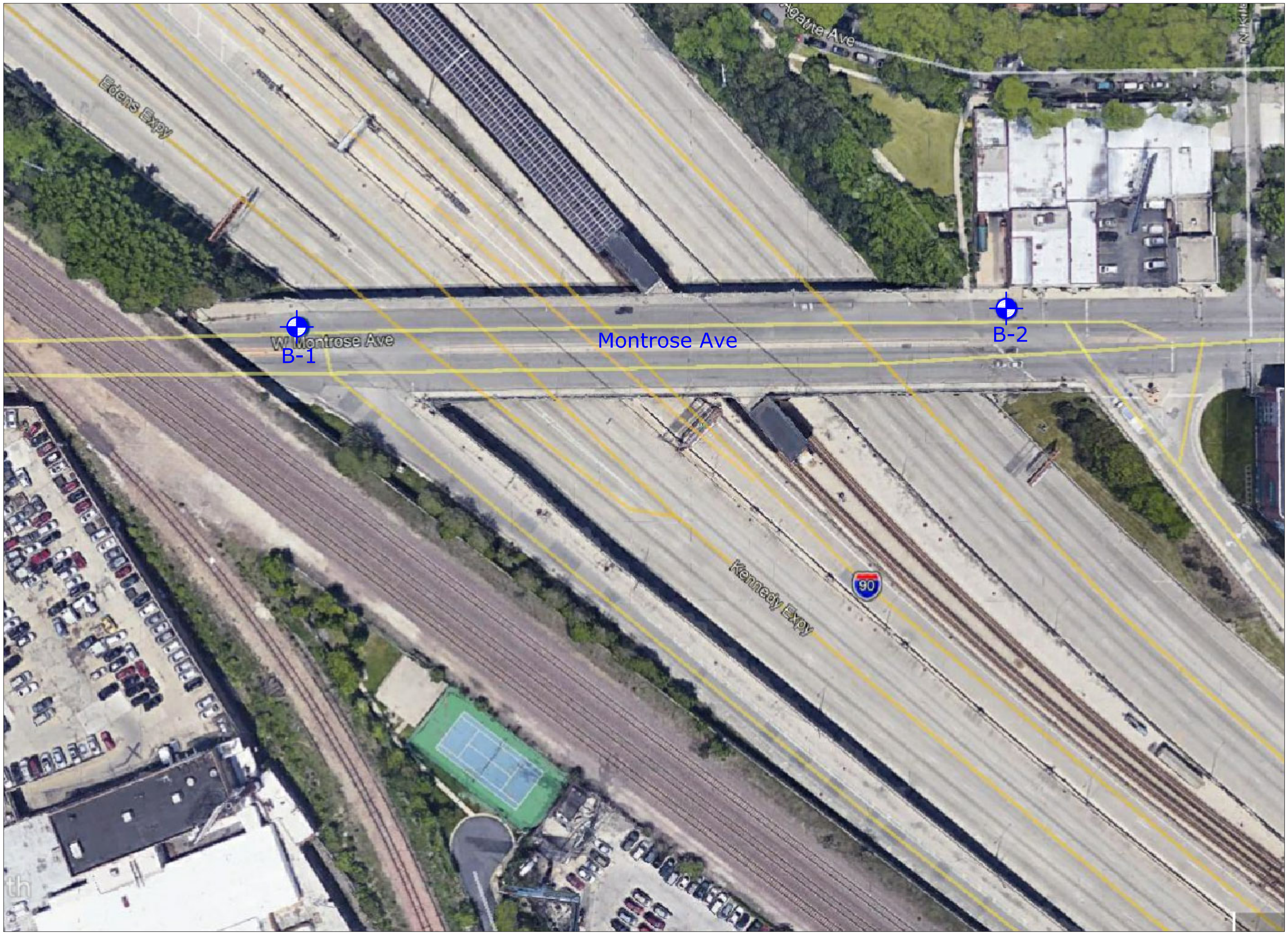
Sincerely,

Min Zhang, Ph.D., P.E.
Project Engineer

Dawn Edgell, P.E.
Sr. Project Engineer

APPENDIX A

BORING LOCATION PLAN



SOIL BORING LOCATION

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SCALE:	DRAWN BY:	
NTS	MZ	APPENDIX A - BORING LOCATION PLAN PROPOSED TEMPORARY SHEET PILING MONTROSE AVENUE OVER FAI 90/94 CHICAGO, ILLINOIS
	CHECKED BY: DE	
	DATE: 3/21/2019	

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APPENDIX B

SOIL BORING LOGS

Illinois Department of Transportation
Division of Highways
GSG Consultants, Inc.

SOIL BORING LOG

Date 3/21/19

ROUTE FAI I-90/94 **DESCRIPTION** West Side of Montrose Avenue Bridge **LOGGED BY** EP

SECTION 267-0101.3-B-R **LOCATION** Montrose Ave, **SEC.** , **TWP.** , **RNG.** ,
Latitude , **Longitude**

COUNTY Cook **DRILLING METHOD** HSA **HAMMER TYPE** AUTO

STRUCT. NO. 016-0852
Station 23+37.66

BORING NO. B-1
Station NA
Offset
Ground Surface Elev. 607.06 ft

Surface Water Elev. NA ft
Stream Bed Elev. NA ft

Groundwater Elev.:
First Encounter None ft
Upon Completion NA ft
After ___ **Hrs.** NA ft

Description	Elev.	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
3.5 inches of Asphalt	606.77				
11.5 inches of Concrete with Rebar	605.81				
Brown, Moist FILL: SAND, with gravel					NR
	603.56				
Very Stiff Brown and Gray, Moist SILTY CLAY, trace gravel (CL/ML)		-5	3 5 6	4.0 B	20
	601.06				
Stiff to Very Stiff Gray, Moist SILTY CLAY, trace gravel (CL/ML)			2 4 5	1.7 B	18
		-10	1 2 3	2.5 B	18
			1 3 3	1.7 B	18
Cobbles at 13.5 feet		-15	3 5 7		18
			2 5 6	1.9 B	20
		-20	2 4 5	1.9 B	20
Stiff to Very Stiff Gray, Moist SILTY CLAY, trace gravel (CL/ML) *(continued)*			2 4 6	1.9 B	15
		-25	2 4 6	2.5 B	14
			3 5 8	3.3 B	14
		-30	3 6 10	4.0 B	17
			3 7 9	3.1 B	18
		-35	3 7 9	3.5 B	18
			2 6 8	2.7 B	13
	567.06	-40	2 4 7	2.3 B	12
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)

Illinois Department of Transportation
Division of Highways
GSG Consultants, Inc.

SOIL BORING LOG

Date 3/19/19

ROUTE FAI I-90/94 **DESCRIPTION** East Side of Montrose Avenue Bridge **LOGGED BY** EP

SECTION 267-0101.3-B-R **LOCATION** Montrose Ave, **SEC.** , **TWP.** , **RNG.** , **Latitude** , **Longitude**

COUNTY Cook **DRILLING METHOD** HSA **HAMMER TYPE** AUTO

STRUCT. NO. 016-0852
Station 23+37.66

BORING NO. B-2
Station NA
Offset
Ground Surface Elev. 609.56 ft

Surface Water Elev. NA ft
Stream Bed Elev. NA ft

Groundwater Elev.:
First Encounter None ft
Upon Completion NA ft
After ___ **Hrs.** NA ft

Description	Elev.	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
3 inches of Asphalt	609.31				
9 inches of Concrete	608.56				
Very Stiff to Hard Brown and Gray, Moist SILTY CLAY, trace gravel (CL/ML)			2 4 6	3.0 P	19
		-5	3 5 8	3.5 P	19
			4 6 9	4.4 B	18
	600.56				
Stiff to Hard Gray, Moist SILTY CLAY, trace gravel (CL/ML)		-10	2 5 8	2.9 B	19
			2 5 6	2.7 B	19
		-15	3 3 6	2.9 B	20
			2 4 6	2.5 B	19
Cobbles from 18.5 to 20 feet		-20	3 5 6	2.0 P	17
Stiff to Hard Gray, Moist SILTY CLAY, trace gravel (CL/ML) *(continued)*			2 5 13	2.5 B	19
		-25	3 7 8	2.7 B	18
			3 6 9	2.1 B	18
		-30	2 6 9	3.3 B	15
			4 7 13	3.3 B	16
		-35	3 8 15	4.2 B	17
			5 9 14	4.2 B	16
Silt seam at 39.5 feet	569.56	-40	5 11 12		21

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)