



Final S4 Report

**Highland Park Avenue over UPRR Bridge Replacement
Iowa DOT Project No. BROS-SWAP-2690(631)SE-94
Fort Dodge, Iowa**

October 7, 2024

Terracon Project No. 08215031-02

Prepared for:

Stanley Consultants, Inc.
Des Moines, Iowa

Prepared by:

Terracon Consultants, Inc.
Des Moines, Iowa



I hereby certify that this engineering document was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the laws of the State of Iowa.

Matthew Cushman

10/7/2024

Matthew D. Cushman, P.E.

Date

My license renewal date is December 31, 2024.



October 7, 2024



Stanley Consultants, Inc.
100 Court Ave., Suite 300
Des Moines, Iowa 50309

Attn: Mr. Dan Fullerton, P.E. – Client Service Manager
E: FullertonDaniel@stanleygroup.com

Re: Final S4 Report
Highland Park Avenue over UPRR Bridge Replacement
Fort Dodge, Iowa
Iowa DOT Project No. BROS-SWAP-2690(631)SE-94
Terracon Project No. 08215031-02

Dear Mr. Fullerton:

We have performed geotechnical engineering services for the referenced project in general accordance with Terracon Proposal No. P08215031rev1, dated June 22, 2021. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning design of driven steel piles for the bridge structure.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

Ujwala Manchikanti

Ujwala Manchikanti, P.E.
Project Engineer

Matthew Cushman

Matthew D. Cushman, P.E.
Senior Engineer

Distribution (electronic):

Stanley Consultants, Inc.

Addressee

Mr. Tony Bower, P.E., bower.tony@stanleygroup.com

Iowa DOT Design Bureau, Soils Section

Mr. Mark Dell, P.E., mark.dell@iowadot.us



REPORT TOPICS

PROJECT INFORMATION	1
DEEP FOUNDATIONS	2
ENGINEERING ANALYSIS	3
GENERAL COMMENTS	5

Note: This report was originally delivered in a web-based format. **Orange Bold** text in the report indicates a referenced section heading. The PDF version also includes hyperlinks which direct the reader to that section and clicking on the **GeoReport** logo will bring you back to this page. For more interactive features, please view your project online at client.terracon.com.

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES
SITE LOCATION AND EXPLORATION PLAN
EXPLORATION RESULTS
SUPPORTING INFORMATION

Note: Refer to each individual Attachment for a listing of contents.

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Fort Dodge, Iowa
Terracon Project No. 08215031-02
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October 7, 2024

PROJECT INFORMATION

In general, the project consists of replacing an existing bridge with a new bridge along Highland Park Avenue in Fort Dodge, Iowa. Our understanding of the project conditions is as follows:

Item	Description
Location	Highland Park Avenue over UPRR, in Fort Dodge (Webster County), Iowa. Latitude/longitude: 42.497139°, -94.171559°
Existing structure	A 124-ft by 27-ft three-span 'wagon wheel' Union Pacific bridge with a substructure consisting of timber and two girder steel beams. The south side of the bridge includes a timber pedestrian crossing.
Proposed structures	A new 144-ft long by 32-ft wide three-span, rolled steel beam bridge with a 10 feet sidewalk. Begin at Station 104+61.71 and end at Station 106+05.71. A retaining wall is planned near the northeast corner of the new bridge and will continue to the east along the north side of S 19 th Street. The planned retaining wall will have a maximum exposed face height of about 8½ feet. Begin at Station 105+70.01 and end at Station 107+23.14
Roadway	The following is included as part of this project. ■ Bridge approach paving will begin at Station 104+58.96 and end at Station 106+25.94. ■ Roadway paving to begin at Station 102+59.60 and end at Station 108+29.85
Grading	Proposed grades along the existing roadway centerline are planned to be near current grades; while fills of up to 5 feet are planned along the existing roadway embankment side slopes.
Slopes	Embankment side slopes and Bridge berm slopes are planned to be 3:1 (horizontal to vertical) or flatter.

DEEP FOUNDATIONS

Based on the soils encountered in the bridge borings (Borings 1, 2, 3, and 4), we anticipate this bridge will be supported on driven steel piles that derive their load carrying capacity through side friction resistance. The following table provides the geotechnical portion of the LRFD design.

Item	Description
LRFD Soil Descriptions	The boring logs include soil descriptions following BDM Table 6.2.7-2. The LRFD soil descriptions correspond to the Iowa DOT's nominal unit geotechnical resistance values for design of friction piles.
Drag Forces	■ West Abutment (Station 104+61.71): considering the bottom of the abutment piles are at elevation 1122.0 feet and about the upper 10 feet of existing soils will induce drag forces on the abutment piles (down to elevation 1115 feet), the drag force would be 8.4 kips on each HP10x57 abutment pile. Drag forces could be eliminated at this location by predrilling the abutment piles by 10 feet. ■ East Abutment (Station 106+05.71): considering the bottom of the abutment piles at elevation 1124.4 feet and about the upper 10 feet of existing soils will induce drag forces on the abutment piles (down to elevation 1116 feet), the drag force would be 10.0 kips on each HP10x57 abutment pile. Drag forces could be eliminated at this location by predrilling the abutment piles by 10 feet. Due to the anticipated drag forces, battered piles should not be used at the abutments. The load factor for drag forces should be 1.0.
Structural Resistance Level (SRL)	We recommend the use of SLR-1, for H-Piles that tip out in firm to very firm glacial clays. Refer to BDM 6.2.6.1
Geotechnical Resistance Factors	We anticipate the generalized soil category for this site will be cohesive (at least 70% of the soil in which the pile penetrates is classified as cohesive according to BDM Table 6.2.8). However, this should be verified by the Structural Engineer after the contract pile lengths are determined. Refer to BDM 6.2.8 and BDM 6.2.9.
Estimated Pile Lengths / Design Tip Elevation	Bridge foundation design loads were unavailable at the time this report was prepared. Therefore, recommended estimated pile lengths, to be listed in the contract documents to provide a basis of bidding, cannot be provided at this time.

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October 7, 2024 ■ Terracon Project No. 08215031-02

Iowa DOT Project No. BROS-SWAP-2690(631)SE-94



Item	Description
Pile Driving / Driving Points	Pile driving should be performed in accordance with Iowa DOT Standard Specifications Section 2501. We expect field verification of pile capacity will be evaluated by using wave equation analyses (WEAP) once the pile driving hammer is determined. On a preliminary basis, we recommend the driving criteria not exceed 120 blows per foot to reduce the potential for damage to the pile driving hammer or the pile during driving. The use of driving points is not anticipated.
Construction Delay / Settlement Plate Locations	None anticipated.

ENGINEERING ANALYSIS

Analysis Conditions

The following conditions were considered in our analyses for this submittal:

- No surcharges due to construction activities or roadway traffic.
- New Class 10 fill materials have the following engineering properties: total unit weight of 130 pcf, friction angle of 12°, and a cohesion of 600 psf; following the Iowa DOT's standard of practice (refer to Iowa DOT Design Manual, Chapter 200E-1).
- MSE walls act as rigid structures and are internally stable (i.e., global slope stability failure planes cannot pass through the reinforced zone).
- MSE wall minimum embedment (to top of leveling pad) is 4 feet (i.e., design frost depth).
- MSE wall heights refer to the distance from the bottom of the wall (top of the leveling pad) to the coping. For abutment walls, the height is measured to the top of pavement.
- MSE wall reinforcement strap length is the greater of 80% of the wall height or 10 feet (based on FHWA NHI-10-024, Table 2-1 Typical Minimum Length of Reinforcement and the Iowa DOT's standard of practice).
- Minimum capacity to demand (C:D) ratio of 1.0 for bearing capacity below MSE walls.
- Minimum acceptable Factor of Safety for global slope stability (refer to Iowa DOT Design Manual, Chapter 200F-1):
 - Short-term (total stress) conditions: 1.3
 - Long-term (effective stress) conditions: 1.5
- Settlement in excess of 0.4 inches will induce drag forces on foundation elements.
- Settlement of up to 1 inch is tolerable for roadway embankments adjacent to bridge structures.

- It's our opinion that settlement resulting from densification of underlying sand layers should occur quickly, likely during construction activities, and therefore should not contribute to post-construction settlement.

Slope Geometry and Material Properties

The existing and proposed cross-section geometries used in our analyses are based on Stanley Consultant's preliminary plans (dated July 23, 2021). The soil layer geometries used in our analysis sections were interpolated or estimated where soil borings were not performed in the immediate vicinity. The estimated short-term and long-term strength parameters for each soil layer are based on our field and laboratory testing, our experience with similar soil types, and on published correlations.

Global Slope Stability Methodology

Global slope stability runs were completed using the computer software "SLOPE/W" developed by GEOSLOPE International Ltd. This program is a finite element software product that calculates the Factors of Safety (FOS) against slope failure along multiple hypothetical (user-defined) circular failure planes, and then 'optimizes' the critical circular failure plane resulting in a composite slip surface (i.e., parts of the critical failure plane are circular while other parts are linear). The FOS results were determined using the Morgenstern-Price methodology (i.e., satisfies both moment equilibrium and force equilibrium).

Settlement Analysis Methodology

Settlement under roadway fills was analyzed by comparing the change in soil stress at the mid-point of each compressible layer to a one-dimensional consolidation test stress-vs.-strain curve and to published correlations for compression index (c_c), recompression index (c_r), and preconsolidation pressure (σ_p), to other engineering properties that may be less susceptible to the effects of sample disturbance (e.g., grain-size analyses, Atterberg limits, natural water content, and unit weight).

The coefficient of consolidation (c_v) for each compressible layer was determined using either the results of a one-dimensional consolidation test or on published correlations provided in NAVFAC 7.1 (Chapter 3, Figure 4, Approximate Correlations for Consolidation Characteristics of Silts and Clays).

The layer thickness of each compressible layer is based on the materials encountered in our borings. New fill zones were treated as trapezoidal areas and our settlement calculations account for stress distribution (both laterally and vertically) using Boussinesq methods.

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Bearing Capacity Analysis Methodology

The required bearing pressure of the mechanically stabilized earth (MSE) retaining wall was unknown at the time this report was written. For our calculations, we have estimated the factored and unfactored bearing pressures as a function of the MSE wall height based on our experience with similar projects. The actual required bearing pressures will be a function of the strap length; shorter reinforcement straps will produce a higher bearing pressure while longer reinforcement straps will produce a lower bearing pressure. The factored LRFD bearing pressures were compared to the underlying soils' factored bearing resistance to determine the capacity to demand (C:D) ratio.

Summary of Analysis Results

Analysis Location	Global Slope Stability Minimum FOS		Bearing Capacity Min. C:D Ratio	Est. Primary Consolidation Settlement (in)	Est. Time to Settlement ≤ 1 Inch	Soils Remediation Required
	Short Term	Long Term				
West Abutment Station 104+50 (Lt.)	5.2	2.5	---	0.6	n/a	No ¹
East Abutment Station 106+25 (Lt.)	2.4	1.5	1.02	0.9	n/a	No ¹
East Abutment Station 106+25 (Rt.)	3.5	2.4	---	0.7		

1. Drag forces will be induced on the bridge's pile foundations unless the abutment piles are predrilled by 10 feet.

GENERAL COMMENTS

Our analysis and opinions are based on our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Natural variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. If variations are noted, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our Scope of Services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of

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pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence or collaboration through this system are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. No warranties, either express or implied, are intended or made.

Site safety, and cost estimating including, excavation support, and dewatering requirements/design are the responsibility of others. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Boring Numbers	Location	Boring Depths (feet)
1, 2, 3 and 4	Bridge	105½ to 110½
5 and 6	Retaining Wall	40½ to 45½

Boring Layout and Elevations: The boring locations were selected and staked on-site by Terracon using hand-held GPS equipment. The existing ground surface elevation at each boring location was determined by interpolating existing ground elevations shown on the roadway cross-section plan sheets developed by Stanley Consultants, Inc. The existing ground surface elevations shown on the boring logs have been rounded to the nearest ½ foot. The locations and elevations of the borings should be considered accurate only to the degree implied by the means and methods used to define them.

Subsurface Exploration Procedures: The borings were drilled with an ATV-mounted drilling rig using continuous flight hollow-stem augers, and mud rotary drilling methods. Soil sampling was performed using thin-walled tube and split-barrel sampling procedures. In the thin-walled tube sampling procedure, a thin-walled, seamless steel tube with a sharp cutting edge is pushed hydraulically into the soil to obtain a relatively undisturbed sample. In the split-barrel sampling procedure, a standard 2-inch outer diameter split-barrel sampling spoon is driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths. The samples were placed in appropriate containers and taken to our laboratory for testing. The boreholes were backfilled with auger cuttings, and pavement penetrations created by our exploration crew were capped with sack-mix concrete.

The drill crew prepared a field log of each boring to record field data including visual descriptions of the materials encountered during drilling as well as the driller's interpretation of the subsurface conditions between samples. The boring logs included with this report represent an interpretation of the subsurface conditions at each boring location based on field and laboratory data, and observation of the samples. Soil layer descriptions for the bridge borings are given for both USCS and Iowa LRFD design tables.

Laboratory Testing

In the laboratory, water content tests were performed on portions of the recovered samples. The dry unit weight of intact, thin-walled tube samples was determined. Unconfined compressive strength and hand penetrometer tests were performed to estimate the consistency of select samples of fine-grained soils. Atterberg limits tests were performed on select samples obtained

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from the site. Results of these laboratory tests are shown on the boring logs at their corresponding sample depths in **Exploration Results**.

Consolidated Undrained (CU) triaxial compression, one-dimensional consolidation, and grain size distribution tests were also performed on select samples. Results of these tests are included as separate graphs in **Exploration Results**.

The samples were described in the laboratory based on visual observation, texture and plasticity, and the laboratory testing described above. The descriptions of the soils and rock indicated on the boring logs are in general accordance with the General Notes, Unified Soil Classification System (USCS), and Description of Rock Properties, each summarized and included in **Supporting Information**.

SITE LOCATION AND EXPLORATION PLAN

Contents:

Site Location

Exploration Plan

Note: All attachments are one page unless noted above.

SITE LOCATION

Highland Park Avenue over UPRR Bridge Replacement ■ Fort Dodge, Iowa
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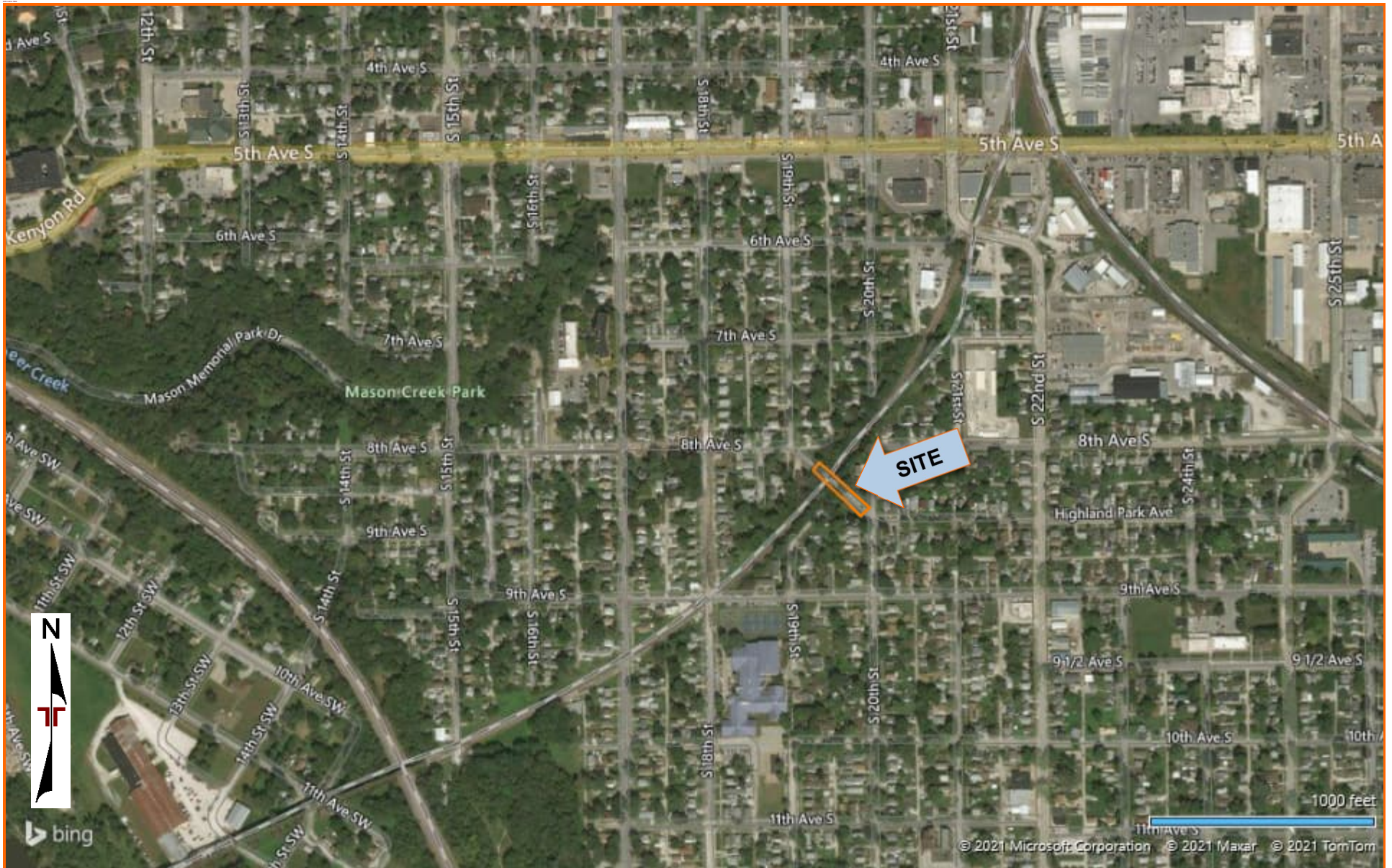


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION PLAN

Highland Park Avenue over UPRR Bridge Replacement ■ Fort Dodge, Iowa
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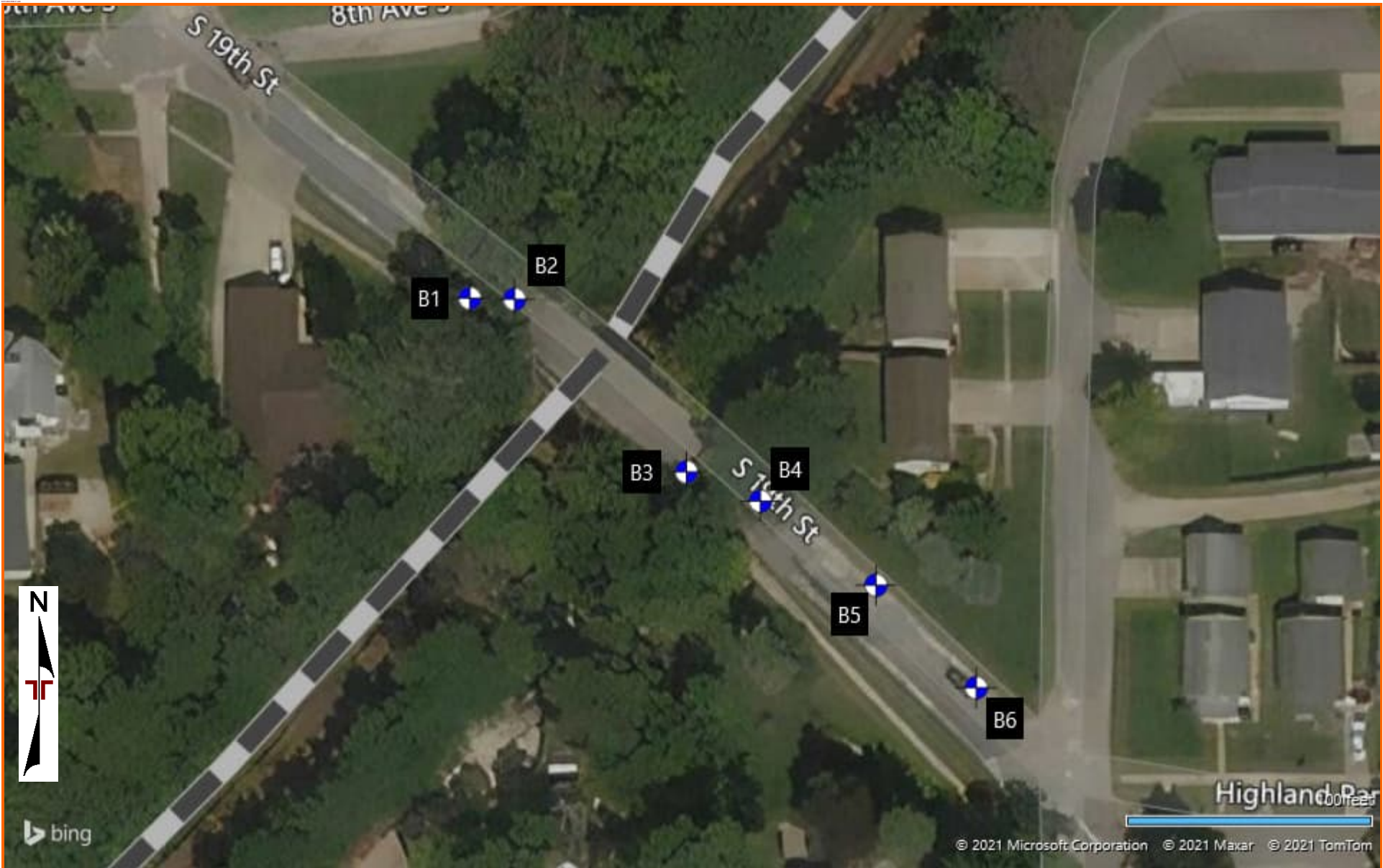


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION RESULTS

Contents:

Boring Logs (Borings 1 through 6) (20 pages)

Grain Size Distribution (2 pages)

One Dimensional Consolidation Test

Consolidated Undrained (CU) Triaxial Test

Note: All attachments are one page unless noted above.

BORING LOG NO. B1

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PROJECT: Highland Park Ave over UPRR Bridge Replacement- BROS-SWAP-2690(631)--SE-94
SITE: Highland Park Avenue
 Fort Dodge, Iowa

CLIENT: Stanley Consultants Inc
 Des Moines, Iowa

GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 42.4972° Longitude: -94.1716°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAMPLE ID	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS
											LL-PL-PI
	Approximate Surface Elev: 1125 (Ft.) +/-										
	DEPTH ELEVATION (Ft.)										
	0.4 1124.5+/-										
	TOPSOIL										
	FILL - DARK GRAY BROWN AND BROWN STIFF CLAY (Fill), moist (USCS: Fill - Sandy Lean Clay, Trace Gravel) (Iowa LRFD Description: Stiff Silty Clay Fill)	5		5		3-2-3 N=5 9000+ (HP)	B1				
				0		2-2-3 N=5	B2				
				7		6500 (HP)	B3	4650	22	98	
	9.0 1116+/-	10		9		2-3-3 N=6	C1				
				14			C2	3290	26	94	
		15		18		3-4-4 N=8	C3				
				17			C4	5320	18	111	
		20		18		4-6-6 N=12	C5				
	21.5 1103.5+/-	25		18		2-3-5 N=8 4500 (HP)	D2				
				18		4000 (HP)	D1	4690	17	113	
				18			D3	3170	18	111	
		30		18		3-4-6	D4				

Stratification lines are approximate. In-situ, the transition may be gradual.
 Classification of rock estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
 0-29' - Hollow Stem Auger
 29-109' - Wash boring

Abandonment Method:
 Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:
 Drill / Abutment

WATER LEVEL OBSERVATIONS

None observed while drilling

Terracon
 600 SW 7th St Ste M
 Des Moines, IA

Boring Started: 09-17-2021

Drill Rig: 709

Project No.: 08215031

Boring Completed: 09-17-2021

Driller: SK

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. IADOT SMART LOG 08215031 HIGHLAND PARK AVE.GPJ IADOT DATATEMPLATE.GDT 10/28/21

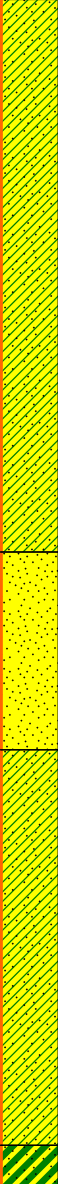
BORING LOG NO. B1

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PROJECT: Highland Park Ave over UPRR Bridge
Replacement- BROS-SWAP-2690(631)--SE-94

CLIENT: Stanley Consultants Inc
Des Moines, Iowa

SITE: Highland Park Avenue
Fort Dodge, Iowa

GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 42.4972° Longitude: -94.1716°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAMPLE ID	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS
											LL-PL-PI
	Approximate Surface Elev: 1125 (Ft.) +/-										
	DEPTH	ELEVATION (Ft.)									
	GRAY FIRM SANDY CLAY (Glacial), moist (USCS: Sandy Lean Clay, Trace Gravel) (Iowa LRFD Description: Firm Glacial Clay) (continued)			■		N=10					
		35		■	18	4-5-5 N=10	D5				
		40		■	18	4-5-6 N=11	D6				
		44.0									
		1081+/-									
				■	14	9-12-10 N=22	E1				
		45									
		49.0									
		1076+/-									
				■	3	3-5-6 N=11	F1				
		50									
		55		■	13	5-6-7 N=13	F2				
		59.0									
		1066+/-									
		60		■	16	5-7-11	G1				

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification of rock estimated from disturbed samples. Core samples and petrographic
analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
0-29' - Hollow Stem Auger
29-109' - Wash boring

Abandonment Method:
Boring backfilled with auger cuttings after delayed water
levels were measured.

WATER LEVEL OBSERVATIONS

None observed while drilling

Notes:

Terracon
600 SW 7th St Ste M
Des Moines, IA

Boring Started: 09-17-2021

Drill Rig: 709

Project No.: 08215031

Boring Completed: 09-17-2021

Driller: SK

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. IADOT SMART LOG 08215031 HIGHLAND PARK AVE GPJ IADOT DATATEMPLATE GDT 10/28/21

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CLIENT: Stanley Consultants Inc
Des Moines, Iowa

[illegible]

		N=18					
BROWN TO GRAY VERY FIRM SANDY CLAY (Glacial), moist (USCS: Sandy Lean to Fat Clay, Trace Gravel) (Iowa LRFD Description: Very Firm Glacial Clay) <i>(continued)</i>	65	■ 14	8-11-10 N=21	G2			
	70	■ 17	8-14-17 N=31	G3			
DARK GRAY TO GRAY BROWN VERY FIRM CLAY (Glacial), moist (USCS: Fat Clay, Trace Sand) (Iowa LRFD Description: Very Firm Glacial Clay)	75	■ 17	8-8-10 N=18	G4			
	80	■ 15	5-8-9 N=17	H1			
	85	■ 18	7-9-10 N=19	H2			
	90	■ 18	12-11-9	I1			

Hammer Type: Automatic

Notes:

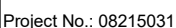
Boring Started: 09-17-2021

Boring Completed: 09-17-2021

Drill Rig: 709

Driller: SK

Project No.: 08215031



BORING LOG NO. B1

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PROJECT: Highland Park Ave over UPRR Bridge
Replacement- BROS-SWAP-2690(631)--SE-94

SITE: Highland Park Avenue
Fort Dodge, Iowa

CLIENT: Stanley Consultants Inc
Des Moines, Iowa

GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 42.4972° Longitude: -94.1716°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAMPLE ID	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS
											LL-PL-PI
	Approximate Surface Elev: 1125 (Ft.) +/-										
	DEPTH ELEVATION (Ft.)										
						N=20					
	GRAY CLAYEY SAND (Glacial), wet (USCS: Clayey Sand) (Iowa LRFD Description: Coarse Sand) (continued)										
	94.0 1031+/-										
	GRAY FINE TO COARSE SAND (Glacial), wet (USCS: Fine to Coarse Sand, Trace Gravel) (Iowa LRFD Description: Glacial Material)	95			12	14-27-31 N=58	J1				
		100			13	11-13-24 N=37	J2				
	105.0 1020+/-	105			10	15-13-8 N=21	J3				
	REDDISH BROWN SHALE										
	110.5 1014.5+/-	110			18	14-19-26 N=45	K1				
	Boring Terminated at 110.5 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification of rock estimated from disturbed samples. Core samples and petrographic
analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
0-29' - Hollow Stem Auger
29-109' - Wash boring

Abandonment Method:
Boring backfilled with auger cuttings after delayed water
levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

None observed while drilling

Terracon

600 SW 7th St Ste M
Des Moines, IA

Boring Started: 09-17-2021

Drill Rig: 709

Project No.: 08215031

Boring Completed: 09-17-2021

Driller: SK

Page 1 of 4

CLIENT: Stanley Consultants Inc
Des Moines, Iowa

GRAPHIC LOG	LOCATION	See Exploration Plan
	Latitude: 42.4972° Longitude: -94.1715°	
Approximate Surface Elev: 1126.5 (Ft.) +/-		
DEPTH	ELEVATION (Ft.)	
0.4	1126+/-	
TOPSOIL		
FILL - DARK BROWN AND GRAY BROWN STIFF CLAY (Fill), moist (USCS: Fill - Lean Clay, With Sand) (Iowa LRFD Description: Stiff Silty Clay Fill)		
A-7-6(18)		
11.5	1115+/-	
GRAY BROWN FIRM SANDY CLAY (Glacial), moist (USCS: Sandy Lean Clay, Trace Gravel) (Iowa LRFD Description: Firm Glacial Clay)		
A-6(6)		
24.0	1102.5+/-	
GRAY FIRM SANDY CLAY (Glacial), moist (USCS: Sandy Lean Clay, Trace Gravel) (Iowa LRFD Description: Firm Glacial Clay)		
Driller's Note: water added to the hollow stem augers at 29 feet		

Hammer Type: Automatic

Project No.: 08215031

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. IADOT_SMART_LOG 08215031 HIGHLAND PARK AVE.GPJ IADOT_DATATEMPLATE.GDT 10/28/21

14' on 09/17/2021

BORING LOG NO. B2

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PROJECT: Highland Park Ave over UPRR Bridge
Replacement- BROS-SWAP-2690(631)--SE-94

CLIENT: Stanley Consultants Inc
Des Moines, Iowa

SITE: Highland Park Avenue
Fort Dodge, Iowa

GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 42.4972° Longitude: -94.1715°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAMPLE ID	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS
											LL-PL-PI
	Approximate Surface Elev: 1126.5 (Ft.) +/-										
	DEPTH	ELEVATION (Ft.)									
	GRAY FIRM SANDY CLAY (Glacial), moist (USCS: Sandy Lean Clay, Trace Gravel) (Iowa LRFD Description: Firm Glacial Clay) (continued)	35		■	18	3-3-6 N=9 4500 (HP)	D4				
		40		■	18	3-4-6 N=10	D5				
		45		■	18	3-5-7 N=12	D6				
		49.0									
		50		■	18	9-12-21 N=33	E1				
		55		■	15	11-18-13 N=31	E2				
		59.0									
		60		■	11	9-10-12	F1				

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification of rock estimated from disturbed samples. Core samples and petrographic
analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
0-29' - Hollow Stem Auger
29- 110' - Wash Boring

Abandonment Method:
Boring backfilled with auger cuttings after delayed water
levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

None observed while drilling

14' on 09/17/2021

Terracon
600 SW 7th St Ste M
Des Moines, IA

Boring Started: 09-16-2021

Drill Rig: 709

Project No.: 08215031

Boring Completed: 09-16-2021

Driller: SK

BORING LOG NO. B2

Page 3 of 4

PROJECT: Highland Park Ave over UPRR Bridge Replacement- BROS-SWAP-2690(631)--SE-94
SITE: Highland Park Avenue
 Fort Dodge, Iowa

CLIENT: Stanley Consultants Inc
 Des Moines, Iowa

GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 42.4972° Longitude: -94.1715°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAMPLE ID	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS
											LL-PL-PI
	Approximate Surface Elev: 1126.5 (Ft.) +/-										
	DEPTH ELEVATION (Ft.)										
	GRAY VERY FIRM SANDY CLAY (Glacial), moist (USCS: Sandy Lean Clay, Trace Gravel) (Iowa LRFD Description: Very Firm Glacial Clay) (continued)	64.0 1062.5+/-		■		N=22					
	BROWN TO GRAY VERY FIRM SANDY CLAY (Glacial), moist (USCS: Sandy Lean to Fat Clay, Trace Gravel) (Iowa LRFD Description: Very Firm Glacial Clay)	65 1062.5+/-		■	12	9-12-12 N=24	G1				
		70		■	13	7-11-13 N=24	G2				
		75		■	14	8-11-16 N=27	G3				
		80		■	18	12-12-12 N=24	G4				
		85		■	18	5-7-11 N=18	H1				
	DARK GRAY TO BLUISH GRAY VERY FIRM CLAY (Glacial), moist (USCS: Fat Clay, Trace Sand) (Iowa LRFD Description: Very Firm Glacial Clay)	84.0 1042.5+/-		■	18	5-8-8	H2				
		90		■	18						

Stratification lines are approximate. In-situ, the transition may be gradual.
 Classification of rock estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
 0-29' - Hollow Stem Auger
 29- 110' - Wash Boring

Abandonment Method:
 Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

None observed while drilling

14' on 09/17/2021

Terracon
 600 SW 7th St Ste M
 Des Moines, IA

Boring Started: 09-16-2021

Drill Rig: 709

Project No.: 08215031

Boring Completed: 09-16-2021

Driller: SK

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. IADOT_SMART_LOG_08215031_HIGHLAND PARK AVE.GPJ IADOT_DATATEMPLATE.GDT 10/28/21

BORING LOG NO. B2

Page 4 of 4

PROJECT: Highland Park Ave over UPRR Bridge
Replacement- BROS-SWAP-2690(631)--SE-94

SITE: Highland Park Avenue
Fort Dodge, Iowa

CLIENT: Stanley Consultants Inc
Des Moines, Iowa

GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 42.4972° Longitude: -94.1715°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAMPLE ID	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS
											LL-PL-PI
	Approximate Surface Elev: 1126.5 (Ft.) +/-										
	DEPTH ELEVATION (Ft.)										
						N=16					
	<u>DARK GRAY TO BLuish GRAY VERY FIRM CLAY</u> (Glacial), moist (USCS: Fat Clay, Trace Sand) (Iowa LRFD Description: Very Firm Glacial Clay) (continued)										
	94.0 1032.5+/-										
	<u>GRAY BROWN FINE TO COARSE SAND</u> (Glacial), moist (USCS: Fine to Coarse Sand, Trace Gravel) (Iowa LRFD Description: Glacial Material)	95			12	9-14-13 N=27	I1				
		100			13	18-28-37 N=65	I2				
		105			16	19-31-29 N=60	I3				
	107.0 1019.5+/-										
	<u>REDDISH BROWN SHALE</u>										
	110.5 1016+/-	110			18	13-22-26 N=48	J1				
	Boring Terminated at 110.5 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification of rock estimated from disturbed samples. Core samples and petrographic
analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
0-29' - Hollow Stem Auger
29- 110' - Wash Boring

Abandonment Method:
Boring backfilled with auger cuttings after delayed water
levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

None observed while drilling

14' on 09/17/2021

Terracon
600 SW 7th St Ste M
Des Moines, IA

Boring Started: 09-16-2021

Drill Rig: 709

Project No.: 08215031

Boring Completed: 09-16-2021

Driller: SK

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. IADOT_SMART_LOG 08215031 HIGHLAND PARK AVE.GPJ IADOT_DATATEMPLATE.GDT 10/28/21

BORING LOG NO. B3

Page 1 of 4

PROJECT: Highland Park Ave over UPRR Bridge
Replacement- BROS-SWAP-2690(631)--SE-94

CLIENT: Stanley Consultants Inc
Des Moines, Iowa

SITE: Highland Park Avenue
Fort Dodge, Iowa

GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 42.497° Longitude: -94.1712°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAMPLE ID	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS
											LL-PL-PI
	Approximate Surface Elev: 1126.5 (Ft.) +/-										
	DEPTH ELEVATION (Ft.)										
	0.7 1126+/-										
	ASPHALT/ GRAVEL										
	FILL - DARK GRAY, GRAY BROWN AND REDDISH BROWN STIFF CLAY (Fill), moist (USCS: Fill - Fat Clay, With Sand, Trace Gravel) (Iowa LRFD Description: Stiff Silty Clay Fill)										
	A-7-6(25) Cec = 0.165, Cer = 0.010										
		5				5000 (HP)	B1	2000	26	96	
						2-2-2 N=4 3000 (HP)	B2				
						CONSOL	B3		26	87	57-24-33
		10				1-2-2 N=4 3500 (HP)	B4				
							B5	1440	21	88	
	13.5 1113+/-					2-3-3 N=6 3000 (HP)	C1				
	GRAY BROWN STIFF SANDY CLAY (Glacial), moist (USCS: Sandy Lean Clay, Trace Gravel) (Iowa LRFD Description: Stiff Sandy Clay) A-6(7) c = 780psf, phi' = 32.4°					CU TRIAX	C2		31	102	35-18-17
		20				2-3-3 N=6	C3				
							C4	2580	19	106	
		25				3-4-4 N=8	C5				
							C6	4950	19	107	
	Driller's Note: water added to the hollow stem augers at 29 feet					4-5-7	C7				
		30									

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
0-29' - Hollow Stem Auger
29-105' - Wash Boring

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with concrete

Notes:
Drill/ Pier

WATER LEVEL OBSERVATIONS

None observed while drilling

16' on 09/16/2021

Terracon
600 SW 7th St Ste M
Des Moines, IA

Boring Started: 09-15-2021

Drill Rig: 709

Project No.: 08215031

Boring Completed: 09-15-2021

Driller: SK

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. IADOT SMART LOG 08215031 HIGHLAND PARK AVE.GPJ IADOT DATATEMPLATE.GDT 10/28/21

BORING LOG NO. B3

Page 2 of 4

PROJECT: Highland Park Ave over UPRR Bridge
Replacement- BROS-SWAP-2690(631)--SE-94

SITE: Highland Park Avenue
Fort Dodge, Iowa

CLIENT: Stanley Consultants Inc
Des Moines, Iowa

GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 42.497° Longitude: -94.1712°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAMPLE ID	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS
											LL-PL-PI
	Approximate Surface Elev: 1126.5 (Ft.) +/-										
	DEPTH ELEVATION (Ft.)										
				X		N=12					
	GRAY BROWN STIFF SANDY CLAY (Glacial), moist (USCS: Sandy Lean Clay, Trace Gravel) (Iowa LRFD Description: Stiff Sandy Clay) <i>(continued)</i>			X	18	3-4-3 N=7 4000 (HP)	D1				
	34.0 1092.5+/-	35		X	13	29-26-7 N=33	D2				
	GRAY VERY FIRM SANDY CLAY (Glacial), moist (USCS: Sandy Lean Clay, Trace Gravel, Occasional Sand Seams) (Iowa LRFD Description: Very Firm Glacial Clay)			X	18	4-8-9 N=17	D3				
		40		X	12	8-10-11 N=21	D4				
		45		X	17	5-7-8 N=15	D5				
		50		X	16	7-11-15	D6				
		55									
		60									

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
0-29' - Hollow Stem Auger
29-105' - Wash Boring

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with concrete

Notes:

WATER LEVEL OBSERVATIONS

None observed while drilling

Terracon

600 SW 7th St Ste M
Des Moines, IA

Boring Started: 09-15-2021

Drill Rig: 709

Project No.: 08215031

Boring Completed: 09-15-2021

Driller: SK

16' on 09/16/2021

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. IADOT_SMART_LOG_08215031_HIGHLAND PARK AVE.GPJ IADOT_DATATEMPLATE.GDT 10/28/21

BORING LOG NO. B3

Page 3 of 4

PROJECT: Highland Park Ave over UPRR Bridge
Replacement- BROS-SWAP-2690(631)--SE-94

SITE: Highland Park Avenue
Fort Dodge, Iowa

CLIENT: Stanley Consultants Inc
Des Moines, Iowa

GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 42.497° Longitude: -94.1712°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAMPLE ID	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS
											LL-PL-PI
	Approximate Surface Elev: 1126.5 (Ft.) +/-										
	DEPTH ELEVATION (Ft.)										
	GRAY VERY FIRM SANDY CLAY (Glacial), moist (USCS: Sandy Lean Clay, Trace Gravel, Occasional Sand Seams) (Iowa LRFD Description: Very Firm Glacial Clay) 64.0 (continued) 1062.5+/-			X		N=26					
	BROWN TO GRAY VERY FIRM SANDY CLAY (Glacial), moist (USCS: Sandy Lean to Fat Clay, Trace Gravel) (Iowa LRFD Description: Very Firm Glacial Clay)	65		X	14	11-13-18 N=31	E1				
		70		X	13	8-15-21 N=36	E2				
		75		X	13	5-9-12 N=21	E3				
		80		X	18	6-7-9 N=16	E4				
	84.0 1042.5+/-	85		X	18	8-11-16 N=27	F1				
	DARK GRAY TO BLUISH GRAY VERY FIRM CLAY (Glacial), moist (USCS: Fat Clay, Trace Sand) (Iowa LRFD Description: Very Firm Glacial Clay)										
		90		X	17	5-6-12	F2				

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
0-29' - Hollow Stem Auger
29-105' - Wash Boring

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with concrete

Notes:

WATER LEVEL OBSERVATIONS

None observed while drilling

16' on 09/16/2021

Terracon
600 SW 7th St Ste M
Des Moines, IA

Boring Started: 09-15-2021

Drill Rig: 709

Project No.: 08215031

Boring Completed: 09-15-2021

Driller: SK

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. IADOT_SMART_LOG_08215031_HIGHLAND PARK AVE.GPJ IADOT_DATATEMPLATE.GDT 10/28/21

BORING LOG NO. B3

Page 4 of 4

PROJECT: Highland Park Ave over UPRR Bridge
Replacement- BROS-SWAP-2690(631)--SE-94

CLIENT: Stanley Consultants Inc
Des Moines, Iowa

SITE: Highland Park Avenue
Fort Dodge, Iowa

GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 42.497° Longitude: -94.1712°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAMPLE ID	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS
											LL-PL-PI
	Approximate Surface Elev: 1126.5 (Ft.) +/-										
	DEPTH ELEVATION (Ft.)										
				X		N=18					
	DARK GRAY TO BLuish GRAY VERY FIRM CLAY (Glacial), moist (USCS: Fat Clay, Trace Sand) (Iowa LRFD Description: Very Firm Glacial Clay) (continued)										
	94.0 1032.5+/-										
	GRAY BROWN FINE TO COARSE SAND (Glacial), wet (USCS: Fine to Coarse Sand, Trace Gravel, With Clay Seams) (Iowa LRFD Description: Glacial Material)	95		X	14	9-13-19 N=32	G1				
		100		X	9	21-28-50/4"	G2				
		105		X	15	11-17-27 N=44	G3				
	105.5 1021+/-										
	Boring Terminated at 105.5 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
0-29' - Hollow Stem Auger
29-105' - Wash Boring

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with concrete

Notes:

WATER LEVEL OBSERVATIONS

None observed while drilling

16' on 09/16/2021

Terracon
600 SW 7th St Ste M
Des Moines, IA

Boring Started: 09-15-2021

Drill Rig: 709

Project No.: 08215031

Boring Completed: 09-15-2021

Driller: SK

BORING LOG NO. B4

Page 1 of 4

PROJECT: Highland Park Ave over UPRR Bridge Replacement- BROS-SWAP-2690(631)--SE-94
SITE: Highland Park Avenue
 Fort Dodge, Iowa

CLIENT: Stanley Consultants Inc
 Des Moines, Iowa

GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 42.497° Longitude: -94.1711°		DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAMPLE ID	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS
	Approximate Surface Elev: 1125.5 (Ft.) +/-											LL-PL-PI
	DEPTH	ELEVATION (Ft.)										
	0.5	1125+/-										
<u>ASPHALT/ GRAVEL</u>												
<u>FILL - GRAY BROWN, DARK BROWN AND DARK GRAY STIFF CLAY</u> (Fill), moist (USCS: Fill - Lean Clay, With Sand, trace gravel) (Iowa LRFD Description: Stiff Silty Clay Fill)												
	11.5	1114+/-	5		☐	3	1500 (HP)	B1		28	92	
					☒	6	1-2-2 N=4 3500 (HP)	B2				
					☐	9	4000 (HP)	B3	1830	30	79	
				10	☒	7	2-3-3 N=6	B4				
					☐	9		C1	2250	20	103	39-17-22
				15	☒	10	2-3-4 N=7	C2				
					☐	19		C3	1950	20	108	
												
			20	☒	18	2-3-3 N=6 3500 (HP)	C4					
					☐	18		C5	1990	20	106	
			25	☒	18	3-5-5 N=10	C6					
					☐	18		D1	6850	19	111	
<u>GRAY STIFF TO FIRM SANDY CLAY</u> (Glacial), moist (USCS: Sandy Lean Clay, Trace Gravel, Occasional Silt Seams) (Iowa LRFD Description: Firm Glacial Clay) Driller's Note: water added to the hollow stem augers at 29 feet												
			30		☒	18	3-4-4	D2				

Stratification lines are approximate. In-situ, the transition may be gradual.
 Classification of rock estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
 0-29' - Hollow Stem Auger
 29-104' - Wash Boring

Abandonment Method:
 Boring backfilled with Auger Cuttings
 Surface capped with concrete

Notes:
 Drill / Abutment

WATER LEVEL OBSERVATIONS

None observed while drilling and at completion

Terracon
 600 SW 7th St Ste M
 Des Moines, IA

Boring Started: 09-14-2021

Drill Rig: 709

Project No.: 08215031

Boring Completed: 09-14-2021

Driller: SK

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. IADOT SMART LOG 08215031 HIGHLAND PARK AVE.GPJ IADOT DATATEMPLATE.GDT 10/28/21

BORING LOG NO. B4

Page 2 of 4

PROJECT: Highland Park Ave over UPRR Bridge Replacement- BROS-SWAP-2690(631)--SE-94
SITE: Highland Park Avenue
 Fort Dodge, Iowa

CLIENT: Stanley Consultants Inc
 Des Moines, Iowa

GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 42.497° Longitude: -94.1711°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAMPLE ID	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS
											LL-PL-PI
	Approximate Surface Elev: 1125.5 (Ft.) +/-										
	DEPTH ELEVATION (Ft.)										
	GRAY STIFF TO FIRM SANDY CLAY (Glacial), moist (USCS: Sandy Lean Clay, Trace Gravel, Occasional Silt Seams) (Iowa LRFD Description: Firm Glacial Clay) (continued)			■		N=8					
		35		■	15	2-3-3 N=6	D3				
		40		■	18	3-4-6 N=10	D4				
	44.0 1081.5+/-			■	16	6-10-9 N=19	E1				
		50		■	17	8-12-8 N=20	E2				
		55		■	18	5-9-9 N=18	F1				
				■	14	6-9-10	G1				
		60									

Stratification lines are approximate. In-situ, the transition may be gradual.
 Classification of rock estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
 0-29' - Hollow Stem Auger
 29-104' - Wash Boring

Abandonment Method:
 Boring backfilled with Auger Cuttings
 Surface capped with concrete

Notes:

WATER LEVEL OBSERVATIONS

None observed while drilling and at completion

Terracon
 600 SW 7th St Ste M
 Des Moines, IA

Boring Started: 09-14-2021

Drill Rig: 709

Project No.: 08215031

Boring Completed: 09-14-2021

Driller: SK

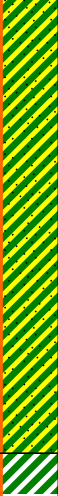
THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. IADOT_SMART_LOG_08215031_HIGHLAND PARK AVE.GPJ IADOT_DATATEMPLATE.GDT 10/28/21

BORING LOG NO. B4

Page 3 of 4

PROJECT: Highland Park Ave over UPRR Bridge Replacement- BROS-SWAP-2690(631)--SE-94
SITE: Highland Park Avenue
 Fort Dodge, Iowa

CLIENT: Stanley Consultants Inc
 Des Moines, Iowa

GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 42.497° Longitude: -94.1711°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAMPLE ID	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS
											LL-PL-PI
	Approximate Surface Elev: 1125.5 (Ft.) +/-										
	DEPTH ELEVATION (Ft.)										
	BROWN TO LIGHT GRAY VERY FIRM SANDY CLAY (Glacial), moist (USCS: Sandy Lean to Fat Clay, Trace Gravel) (Iowa LRFD Description: Very Firm Glacial Clay) (continued)	65		■	17	8-15-19 N=34	G2				
	DARK GRAY VERY FIRM SANDY CLAY (Glacial), moist (USCS: Sandy Fat Clay, Trace Gravel) (Iowa LRFD Description: Very Firm Glacial Clay)	80		■	18	5-8-6 N=14	H1				
		85		■	0	11-18-19 N=37	H2				
		90		■	13	7-7-9	I1				

Stratification lines are approximate. In-situ, the transition may be gradual.
 Classification of rock estimated from disturbed samples. Core samples and petrographic analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
 0-29' - Hollow Stem Auger
 29-104' - Wash Boring

Abandonment Method:
 Boring backfilled with Auger Cuttings
 Surface capped with concrete

Notes:

WATER LEVEL OBSERVATIONS

None observed while drilling and at completion

Terracon
 600 SW 7th St Ste M
 Des Moines, IA

Boring Started: 09-14-2021

Drill Rig: 709

Project No.: 08215031

Boring Completed: 09-14-2021

Driller: SK

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. IADOT_SMART_LOG_08215031_HIGHLAND PARK AVE.GPJ IADOT_DATATEMPLATE.GDT 10/28/21

BORING LOG NO. B4

Page 4 of 4

PROJECT: Highland Park Ave over UPRR Bridge
Replacement- BROS-SWAP-2690(631)--SE-94

SITE: Highland Park Avenue
Fort Dodge, Iowa

CLIENT: Stanley Consultants Inc
Des Moines, Iowa

GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 42.497° Longitude: -94.1711°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAMPLE ID	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS
											LL-PL-PI
	Approximate Surface Elev: 1125.5 (Ft.) +/-										
	DEPTH ELEVATION (Ft.)										
	LIGHT GRAY VERY FIRM CLAY (Glacial), moist (USCS: Fat Clay, Trace Sand) (Iowa LRFD Description: Very Firm Glacial Clay) (continued)	94.0 1031.5+/-		■		N=16					
	GRAY BROWN FINE TO COARSE SAND (Glacial), wet (USCS: Fine to Coarse Sand, Trace Gravel) (Iowa LRFD Description: Glacial Material)	95 1023.5+/-		■	16	12-21-26 N=47	J1				
	REDDISH BROWN SHALE	100 1020+/-		■	11	14-23-34 N=57	J2				
	Boring Terminated at 105.5 Feet	105 1020+/-		■	9	10-11-10 N=21	K1				

Stratification lines are approximate. In-situ, the transition may be gradual.
Classification of rock estimated from disturbed samples. Core samples and petrographic
analysis may reveal other rock types.

Hammer Type: Automatic

Advancement Method:
0-29' - Hollow Stem Auger
29-104' - Wash Boring

Abandonment Method:
Boring backfilled with Auger Cuttings
Surface capped with concrete

Notes:

WATER LEVEL OBSERVATIONS

None observed while drilling and at completion

Terracon
600 SW 7th St Ste M
Des Moines, IA

Boring Started: 09-14-2021

Drill Rig: 709

Project No.: 08215031

Boring Completed: 09-14-2021

Driller: SK

BORING LOG NO. B5

Page 1 of 2

PROJECT: Highland Park Ave over UPRR Bridge Replacement- BROS-SWAP-2690(631)--SE-94

CLIENT: Stanley Consultants Inc
Des Moines, Iowa

SITE: Highland Park Avenue
Fort Dodge, Iowa

GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 42.4969° Longitude: -94.1709°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAMPLE ID	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS
											LL-PL-PI
	Approximate Surface Elev: 1122 (Ft.) +/-										
	DEPTH ELEVATION (Ft.)										
	0.4 1121.5+/-										
	TOPSOIL										
	FILL - DARK BROWN AND GRAY STIFF SANDY CLAY (Fill), moist (USCS: Fill - Sandy Lean Clay, Trace Gravel)										
		5				1-2-1 N=3 8000 (HP)	B1				
		10				1-2-3 N=5 3000 (HP)	B2				
		15				2-2-4 N=6 3500 (HP)	C1				
	GRAY BROWN STIFF SANDY CLAY (Glacial), moist (USCS: Sandy Lean Clay, Trace Gravel)										
		20				3-6-6 N=12	D1				
	GRAY STIFF SANDY CLAY (Glacial), moist (USCS: Sandy Lean Clay, Trace Gravel)										
		25				3-4-4 N=8	D2				
		30				3-1-3	D3				

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
0-44' - Hollow Stem

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:

Drill/ Retaining Wall

WATER LEVEL OBSERVATIONS

- 34' While Drilling
- 38' At completion of drilling
- 26' on 09/14/2021
- Cave in @ 30' on 9/14/2021

Terracon
600 SW 7th St Ste M
Des Moines, IA

Boring Started: 09-13-2021

Boring Completed: 09-13-2021

Drill Rig: 709

Driller: SK

Project No.: 08215031

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. IADOT SMART LOG 08215031 HIGHLAND PARK AVE GPJ IADOT DATATEMPLATE GDT 10/28/21

BORING LOG NO. B5

Page 2 of 2

PROJECT: Highland Park Ave over UPRR Bridge
Replacement- BROS-SWAP-2690(631)--SE-94

SITE: Highland Park Avenue
Fort Dodge, Iowa

CLIENT: Stanley Consultants Inc
Des Moines, Iowa

GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 42.4969° Longitude: -94.1709°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAMPLE ID	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS
											LL-PL-PI
	Approximate Surface Elev: 1122 (Ft.) +/-										
	DEPTH ELEVATION (Ft.)										
				■		N=4					
	GRAY STIFF SANDY CLAY (Glacial), moist (USCS: Sandy Lean Clay, Trace Gravel) <i>(continued)</i>										
	- trace silt seam @ about 34 feet										
		35		■		3-7-4 N=11	D4				
		40		■		6-7-7 N=14	E1				
		45		■		4-9-7 N=16	E2				
	Boring Terminated at 45.5 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
0-44' - Hollow Stem

Abandonment Method:
Boring backfilled with auger cuttings after delayed water
levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

34' While Drilling
38' At completion of drilling
26' on 09/14/2021
Cave in @ 30' on 9/14/2021

Terracon
600 SW 7th St Ste M
Des Moines, IA

Boring Started: 09-13-2021

Boring Completed: 09-13-2021

Drill Rig: 709

Driller: SK

Project No.: 08215031

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. IADOT_SMART_LOG_08215031 HIGHLAND PARK AVE.GPJ IADOT_DATATEMPLATE.GDT 10/28/21

BORING LOG NO. B6

Page 1 of 2

PROJECT: Highland Park Ave over UPRR Bridge Replacement- BROS-SWAP-2690(631)--SE-94
SITE: Highland Park Avenue Fort Dodge, Iowa

CLIENT: Stanley Consultants Inc Des Moines, Iowa

GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 42.4968° Longitude: -94.1708°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAMPLE ID	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS
											LL-PL-PI
	Approximate Surface Elev: 1119 (Ft.) +/-										
	DEPTH ELEVATION (Ft.)										
0.4	TOPSOIL	1118.5+/-									
	FILL - DARK GRAY SANDY CLAY (Fill), moist (USCS: Fill - Sandy Lean Clay, Trace Gravel and organics)										
5				6		2-2-2 N=4 4000 (HP)	B1				
9.0	GRAY BROWN CLAYEY SAND (Glacial), wet (USCS: Clayey Sand, Trace Gravel)	1110+/-		13		1-1-1 N=2	C1				
14.0	GRAY BROWN STIFF SANDY CLAY (Glacial), moist (USCS: Sandy Lean Clay, Trace Gravel)	1105+/-		18		1-3-4 N=7	D1				
19.0	GRAY FIRM SANDY CLAY (Glacial), moist (USCS: Sandy Lean Clay, Trace Gravel)	1100+/-		18		3-5-5 N=10	E1				
25				18		3-4-4 N=8	E2				
30				18		4-5-6	E3				

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
0-39' Hollow Stem Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water levels were measured.

Notes:
Drill/ Retaining Wall

WATER LEVEL OBSERVATIONS

9' While Drilling
 Dry at completion of drilling
 8' on 09/14/2021
 Cave in @ 21' on 9/14/2021

Terracon
 600 SW 7th St Ste M
 Des Moines, IA

Boring Started: 09-13-2021

Boring Completed: 09-13-2021

Drill Rig: 709

Driller: SK

Project No.: 08215031

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. IADOT SMART LOG 08215031 HIGHLAND PARK AVE GPJ IADOT DATATEMPLATE GDT 10/28/21

BORING LOG NO. B6

Page 2 of 2

PROJECT: Highland Park Ave over UPRR Bridge
Replacement- BROS-SWAP-2690(631)--SE-94

SITE: Highland Park Avenue
Fort Dodge, Iowa

CLIENT: Stanley Consultants Inc
Des Moines, Iowa

GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 42.4968° Longitude: -94.1708°	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAMPLE ID	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS
											LL-PL-PI
	Approximate Surface Elev: 1119 (Ft.) +/-										
	DEPTH	ELEVATION (Ft.)									
	GRAY FIRM SANDY CLAY (Glacial), moist (USCS: Sandy Lean Clay, Trace Gravel) <i>(continued)</i>	35		■	18	2-3-7 N=10	E4				
	40.5	1078.5+/-		■	18	6-7-7 N=14	E5				
Boring Terminated at 40.5 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
0-39' Hollow Stem Auger

Abandonment Method:
Boring backfilled with auger cuttings after delayed water
levels were measured.

Notes:

WATER LEVEL OBSERVATIONS

9' While Drilling
Dry at completion of drilling
8' on 09/14/2021
Cave in @ 21' on 9/14/2021

Terracon
600 SW 7th St Ste M
Des Moines, IA

Boring Started: 09-13-2021

Boring Completed: 09-13-2021

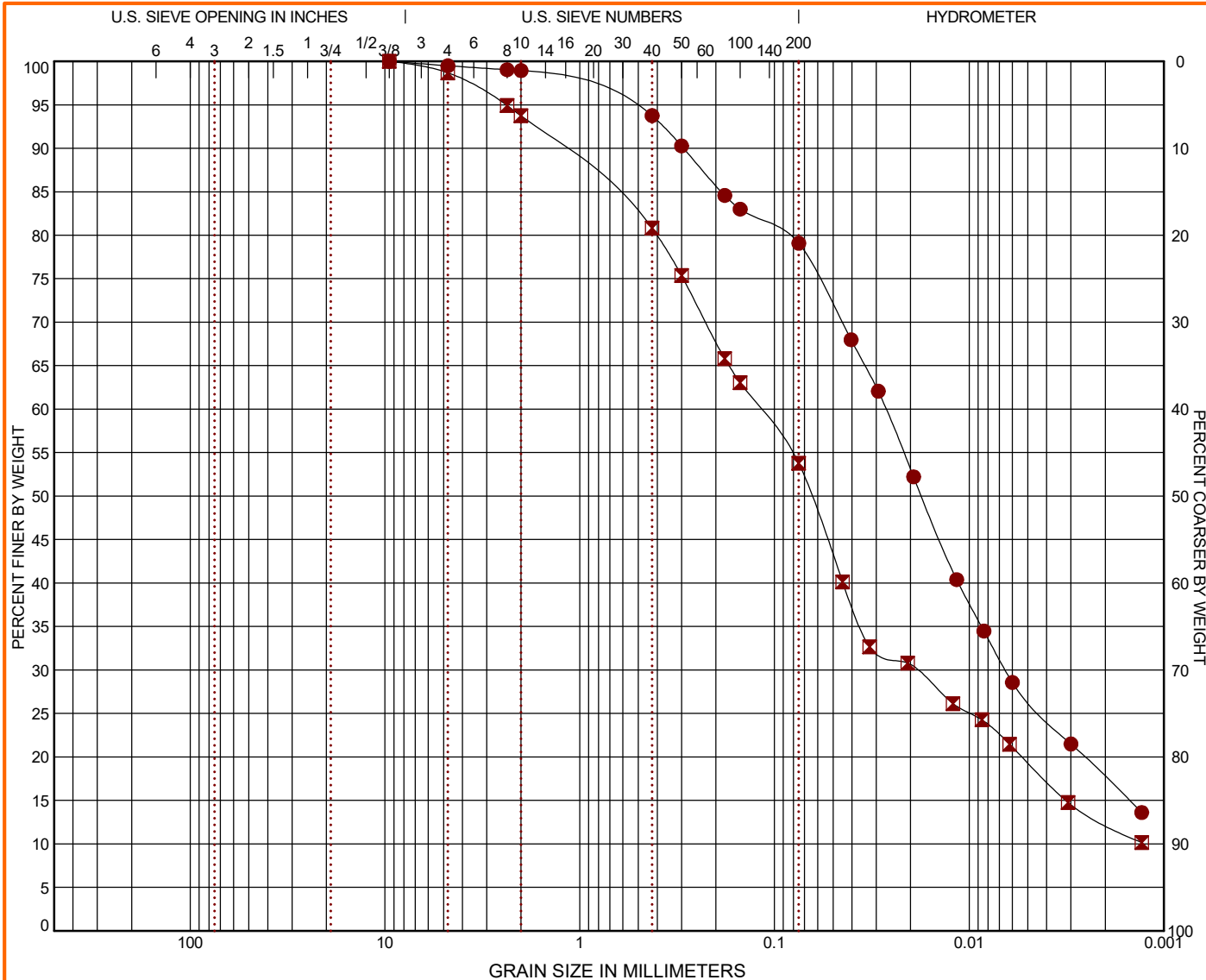
Drill Rig: 709

Driller: SK

Project No.: 08215031

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
B2	6.5 - 8.5	0.0	0.5	20.4	52.4		26.7	CL
B2	16.5 - 18.5	0.0	1.3	44.9	34.4		19.4	CL

GRAIN SIZE			
	●	■	
D ₆₀	0.027	0.119	
D ₃₀	0.007	0.019	
D ₁₀			

COEFFICIENTS			
	●	■	
C _c			
C _u			

Sieve	% Finer	Sieve	% Finer	Sieve	% Finer
3/8"	100.0	3/8"	100.0		
#4	99.49	#4	98.68		
#8	99.03	#8	94.92		
#10	98.93	#10	93.73		
#40	93.75	#40	80.82		
#50	90.26	#50	75.36		
#80	84.57	#80	65.81		
#100	83.0	#100	63.06		
#200	79.08	#200	53.78		

SOIL DESCRIPTION	
●	LEAN CLAY with SAND (CL)
■	SANDY LEAN CLAY (CL)

REMARKS	
●	
■	

PROJECT: Highland Park Ave over UPRR
Bridge Replacement-
BROS-SWAP-2690(631)-SE-94

SITE: Highland Park Avenue
Fort Dodge, Iowa

Terracon
600 SW 7th St Ste M
Des Moines, IA

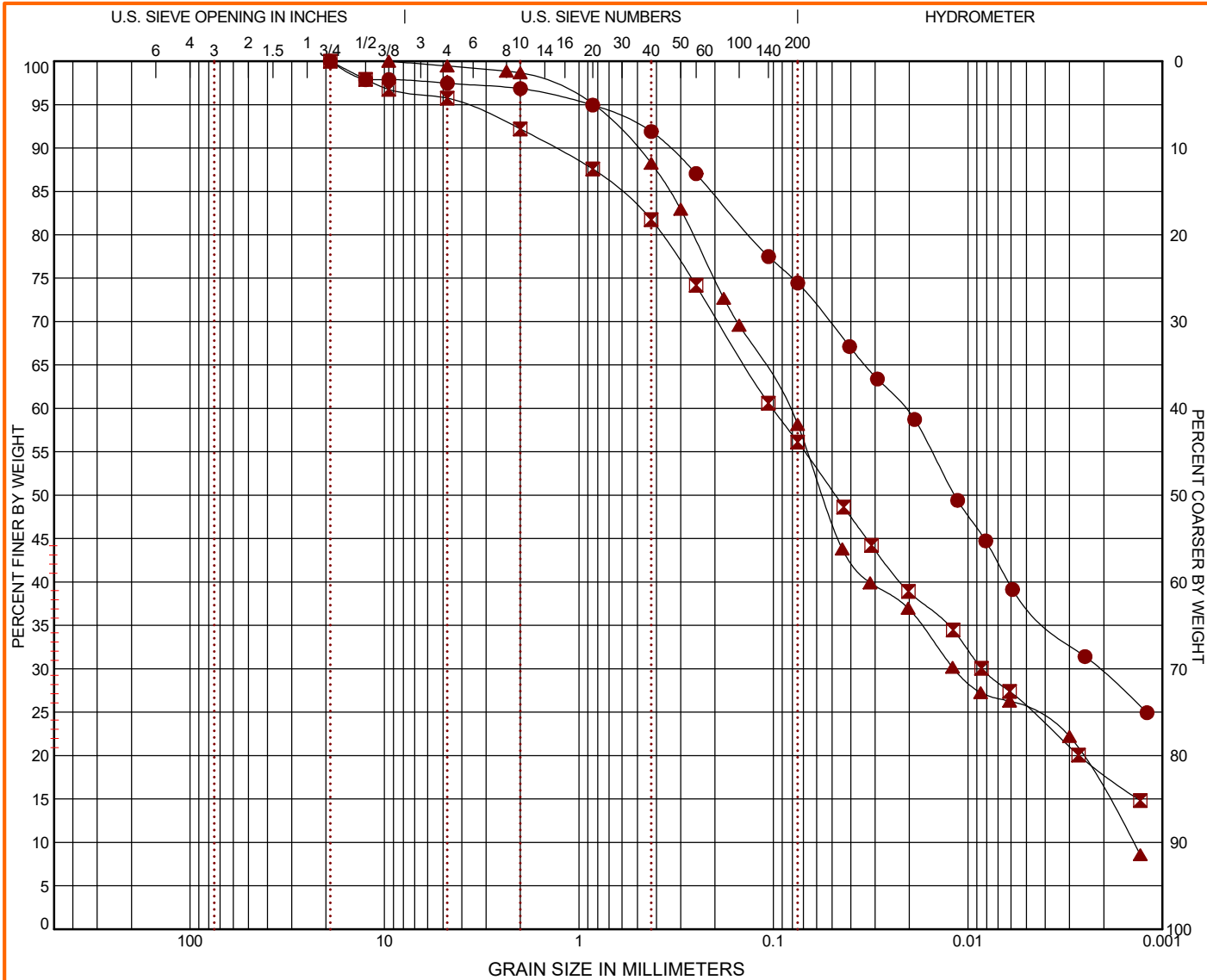
PROJECT NUMBER: 08215031

CLIENT: Stanley Consultants Inc
Des Moines, Iowa

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS 1 08215031 HIGHLAND PARK AVE.GPJ IADOT_DATATEMPLATE.GDT 10/28/21

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
● 3	6.5 - 8.5	0.0	2.5	23.0	36.8		37.7	CH
☒ 3	16.5 - 18.5	0.0	4.3	39.6	30.5		25.6	CL
▲ 4	11.5 - 13.5	0.0	0.6	41.3	33.0		25.1	CL

GRAIN SIZE			
	●	☒	▲
D ₆₀	0.021	0.101	0.084
D ₃₀	0.002	0.008	0.012
D ₁₀			0.001

COEFFICIENTS			
	●	☒	▲
C _c			1.16
C _u			59.14

Sieve	% Finer	Sieve	% Finer	Sieve	% Finer
3/4"	100.0	3/4"	100.0	3/8"	100.0
1/2"	97.87	1/2"	97.91	#4	99.45
3/8"	97.87	3/8"	96.75	#8	98.86
#4	97.46	#4	95.74	#10	98.66
#10	96.84	#10	92.19	#40	88.24
#20	94.94	#20	87.58	#50	82.95
#40	91.9	#40	81.74	#80	72.68
#60	87.05	#60	74.18	#100	69.59
#140	77.49	#140	60.59	#200	58.16
#200	74.45	#200	56.14		

SOIL DESCRIPTION	
●	FAT CLAY with SAND (CH)
☒	SANDY LEAN CLAY (CL)
▲	SANDY LEAN CLAY (CL)
REMARKS	
●	
☒	
▲	

PROJECT: Highland Park Ave over UPRR
Bridge Replacement

SITE: Highland Park Avenue
Fort Dodge, Iowa

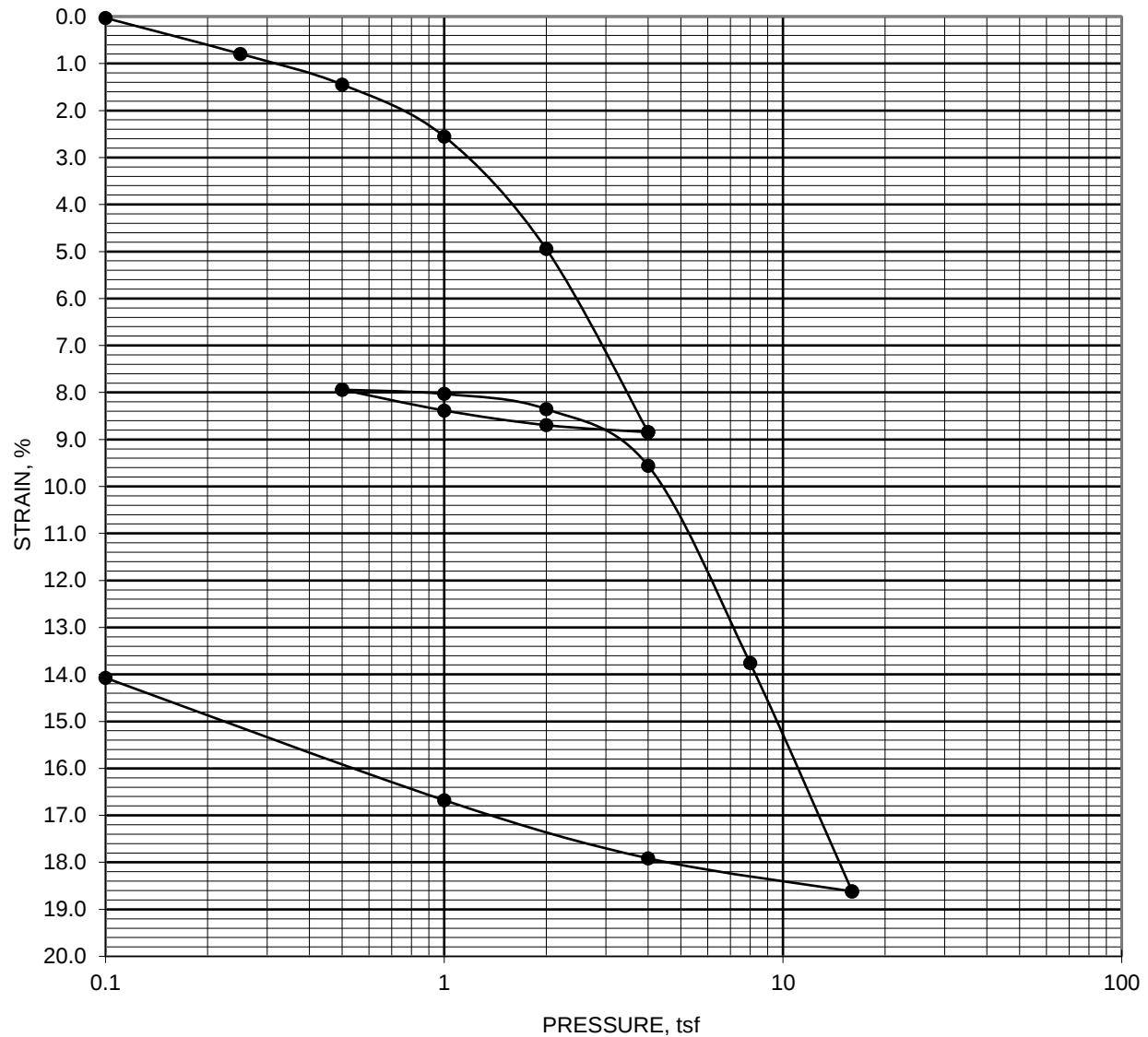
Terracon
600 SW 7th St Ste M
Des Moines, IA

PROJECT NUMBER: 08215031

CLIENT: Stanley Consultants Inc
Des Moines, Iowa

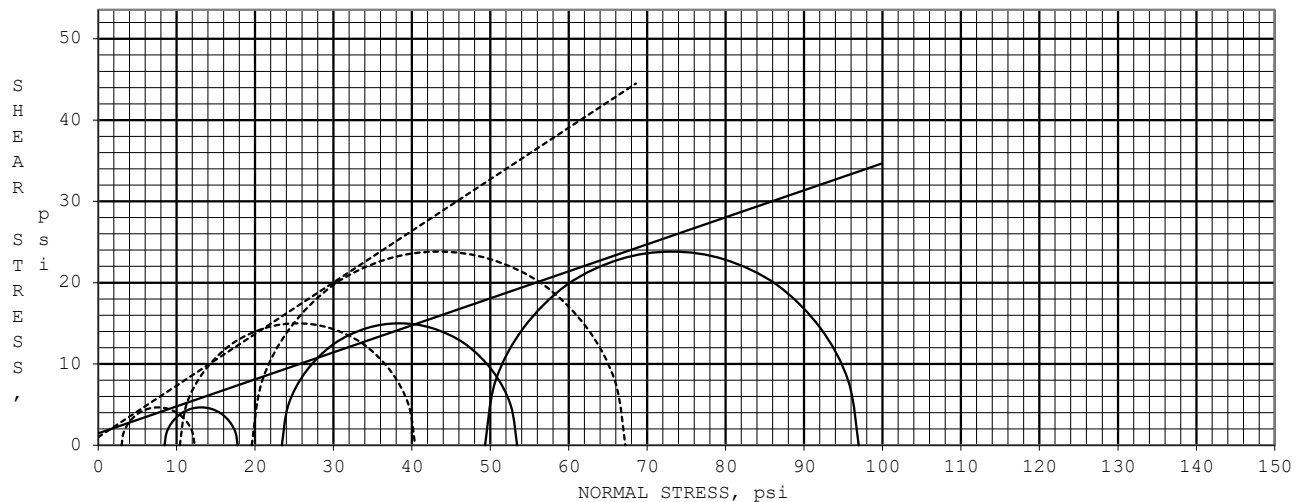
LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS 1 08215031 HIGHLAND PARK AVE.GPJ IADOT_DATATEMPLATE.GDT 10/1/21

**ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF COHESIVE SOILS
ASTM D2435**

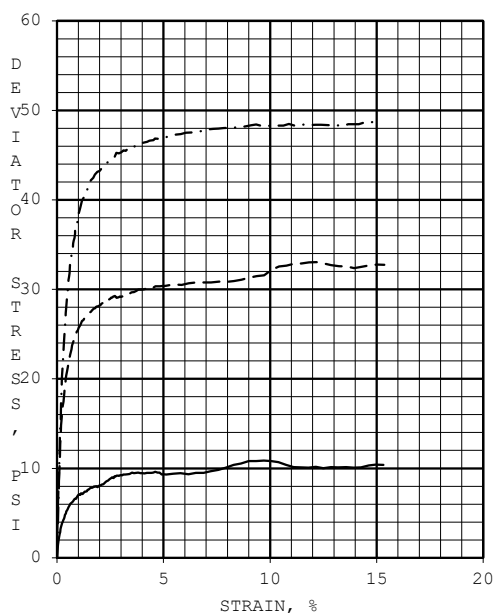


DIAMETER, mm	63.45	HEIGHT, mm	25.27	PROPERTY		BEFORE TEST	AFTER TEST
OVERBURDEN PRESSURE, tsf		0.41		MOISTURE, %		26.0	24.7
PRECONSOL. PRESSURE, tsf		1.49		DRY DENSITY, pcf		86.7	99.1
OVER CONSOLIDATION RATIO		3.6		SATURATION, %		74	98
COMPRESSION INDEX		0.319		VOID RATIO		0.943	0.669
REBOUND INDEX		0.020		SAMPLE TYPE		UNDISTURBED	
LIQUID LIMIT	57	PLASTIC LIMIT	24	PLASTICITY INDEX	33	SPECIFIC GRAVITY	2.7 ESTIMATED
SAMPLE DESCRIPTION FAT CLAY WITH SAND (CL), 10YR 2/2 VERY DARK BROWN TRACE 2.5Y 4/6 OLIVE BROWN							
BORING NO.	B-3		SAMPLE NO.	3		DEPTH, feet	6.5 - 8.5

**HIGHLAND PARK AVE OVER UPRR BRIDGE
REPLACEMENT FORT DOGE, IOWA
08215031
10/14/2021**



EFFECTIVE STRESS ---	ANGLE OF INTERNAL FRICTION, deg	32.4	COHESION, psi	1.0
TOTAL STRESS —	ANGLE OF INTERNAL FRICTION, deg	18.4	COHESION, psi	1.5



SPECIMEN ID:		A	B	C
INITIAL	WATER CONTENT, %	22.1	20.5	19.8
	DRY DENSITY, pcf	96.1	104.3	106.4
	SATURATION, %	79	90	92
	VOID RATIO	0.75	0.62	0.58
BEFORE SHEAR	WATER CONTENT, %	26.6	20.4	18.7
	DRY DENSITY, pcf	98.1	108.6	111.9
	SATURATION (B PARAMETER)	0.98	0.95	0.99
	VOID RATIO	0.72	0.55	0.51
	FINAL BACK PRESSURE, psi	101.3	101.4	99.4
MINOR PRINCIPAL STRESS, psi		8.5	23.4	49.3
EFFECTIVE STRESS PEAK AT % STRAIN		3.2	3.8	6.6
EFF. DEVIATOR STRESS AT PEAK STRAIN, psi		9.3	30.0	47.6
TOTAL STRESS PEAK AT % STRAIN		3.2	3.8	6.6
TOTAL DEVIATOR STRESS AT PEAK STRAIN, psi		9.3	30.0	47.6
ULTIMATE DEVIATOR STRESS (15% STR), psi		10.4	32.7	48.7
TIME TO 50% PRIMARY CONSOLIDATION, min		0.63	2.00	2.30
STRAIN RATE, % / hour		2.66	2.67	2.69
INITIAL DIAMETER, inch		1.968	1.977	1.948
INITIAL HEIGHT, inch		3.932	3.984	3.998
AREA AFTER CONSOLIDATION, inch ²		2.999	2.980	2.875
PROJECT NO. 08215031		PROJECT: HIGHLAND PARK AVE OVER UPRR BRIDGE REPLACEMENT		
		FORT DODGE, IOWA		
		BORING #: B-3		
LABORATORY: TERRACON - LENEXA		SAMPLE #: 7		
DATE: 6/11/2020		DEPTH, feet: 16.5 - 18.5		

PROCEDURE: ASTM D4767, CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST ON COHESIVE SOILS

Terracon

SUPPORTING INFORMATION

Contents:

General Notes

Unified Soil Classification System

Description of Rock Properties

Note: All attachments are one page unless noted above.

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

Highland Park Over UPRR

Des Moines, IA

Terracon Project No. 08215031

SAMPLING	WATER LEVEL	FIELD TESTS
 Shelby Tube  Split Spoon	 Water Initially Encountered  Water Level After a Specified Period of Time  Water Level After a Specified Period of Time  Cave In Encountered Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.	N Standard Penetration Test Resistance (Blows/Ft.) (HP) Hand Penetrometer (T) Torvane (DCP) Dynamic Cone Penetrometer UC Unconfined Compressive Strength (PID) Photo-Ionization Detector (OVA) Organic Vapor Analyzer

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification as noted on the soil boring logs is based Unified Soil Classification System. Where sufficient laboratory data exist to classify the soils consistent with ASTM D2487 "Classification of Soils for Engineering Purposes" this procedure is used. ASTM D2488 "Description and Identification of Soils (Visual-Manual Procedure)" is also used to classify the soils, particularly where insufficient laboratory data exist to classify the soils in accordance with ASTM D2487. In addition to USCS classification, coarse grained soils are classified on the basis of their in-place relative density, and fine-grained soils are classified on the basis of their consistency. See "Strength Terms" table below for details. The ASTM standards noted above are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

LOCATION AND ELEVATION NOTES

Exploration point locations as shown on the Exploration Plan and as noted on the soil boring logs in the form of Latitude and Longitude are approximate. See [Exploration and Testing Procedures](#) in the report for the methods used to locate the exploration points for this project. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
Descriptive Term (Density)	Standard Penetration or N-Value Blows/Ft.	Descriptive Term (Consistency)	Unconfined Compressive Strength Qu, (psf)	Standard Penetration or N-Value Blows/Ft.
Very Loose	0 - 3	Very Soft	less than 500	0 - 1
Loose	4 - 9	Soft	500 to 1,000	2 - 4
Medium Dense	10 - 29	Medium Stiff	1,000 to 2,000	4 - 8
Dense	30 - 50	Stiff	2,000 to 4,000	8 - 15
Very Dense	> 50	Very Stiff	4,000 to 8,000	15 - 30
		Hard	> 8,000	> 30

RELEVANCE OF SOIL BORING LOG

The soil boring logs contained within this document are intended for application to the project as described in this document. Use of these soil boring logs for any other purpose may not be appropriate.

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests ^A					Soil Classification	
					Group Symbol	Group Name ^B
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	Gravels: More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels: Less than 5% fines ^C	$Cu \geq 4$ and $1 \leq Cc \leq 3$ ^E	GW	Well-graded gravel ^F	
			$Cu < 4$ and/or $[Cc < 1 \text{ or } Cc > 3.0]$ ^E	GP	Poorly graded gravel ^F	
		Gravels with Fines: More than 12% fines ^C	Fines classify as ML or MH	GM	Silty gravel ^{F, G, H}	
			Fines classify as CL or CH	GC	Clayey gravel ^{F, G, H}	
	Sands: 50% or more of coarse fraction passes No. 4 sieve	Clean Sands: Less than 5% fines ^D	$Cu \geq 6$ and $1 \leq Cc \leq 3$ ^E	SW	Well-graded sand ^I	
			$Cu < 6$ and/or $[Cc < 1 \text{ or } Cc > 3.0]$ ^E	SP	Poorly graded sand ^I	
		Sands with Fines: More than 12% fines ^D	Fines classify as ML or MH	SM	Silty sand ^{G, H, I}	
			Fines classify as CL or CH	SC	Clayey sand ^{G, H, I}	
Fine-Grained Soils: 50% or more passes the No. 200 sieve	Silts and Clays: Liquid limit less than 50	Inorganic:	$PI > 7$ and plots on or above “A”	CL	Lean clay ^{K, L, M}	
			$PI < 4$ or plots below “A” line ^J	ML	Silt ^{K, L, M}	
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay ^{K, L, M, N}
			Liquid limit - not dried			Organic silt ^{K, L, M, O}
	Silts and Clays: Liquid limit 50 or more	Inorganic:	PI plots on or above “A” line	CH	Fat clay ^{K, L, M}	
			PI plots below “A” line	MH	Elastic Silt ^{K, L, M}	
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay ^{K, L, M, P}
			Liquid limit - not dried			Organic silt ^{K, L, M, Q}
Highly organic soils:	Primarily organic matter, dark in color, and organic odor			PT	Peat	

^A Based on the material passing the 3-inch (75-mm) sieve.

^B If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

^C Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

^D Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay.

$$E \quad Cu = D_{60}/D_{10} \quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$$

^F If soil contains $\geq 15\%$ sand, add "with sand" to group name.

^G If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

^H If fines are organic, add "with organic fines" to group name.

^I If soil contains $\geq 15\%$ gravel, add "with gravel" to group name.

^J If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

^K If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

^L If soil contains $\geq 30\%$ plus No. 200 predominantly sand, add "sandy" to group name.

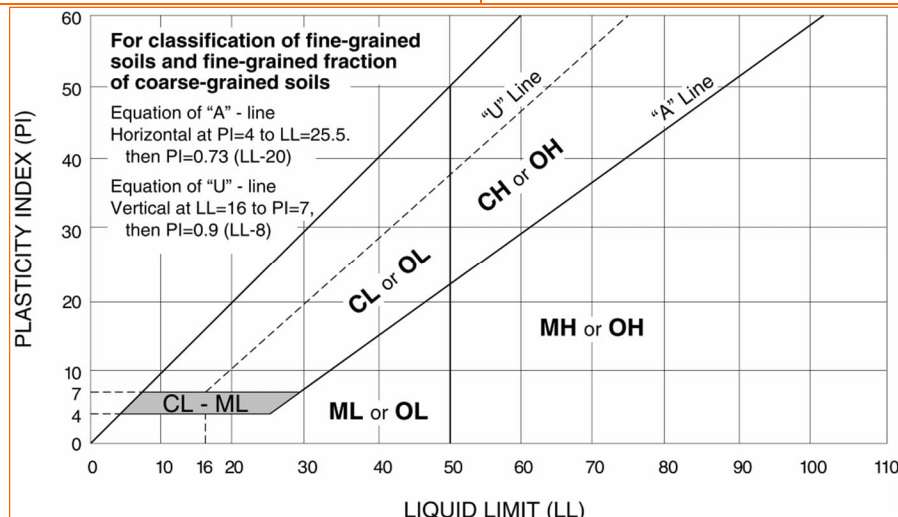
^M If soil contains $\geq 30\%$ plus No. 200, predominantly gravel, add "gravelly" to group name.

^N $PI \geq 4$ and plots on or above "A" line.

^O $PI < 4$ or plots below "A" line.

^P PI plots on or above "A" line.

^Q PI plots below "A" line.



WEATHERING

Fresh	Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer if crystalline.
Very slight	Rock generally fresh, joints stained, some joints may show thin clay coatings, crystals in broken face show bright. Rock rings under hammer if crystalline.
Slight	Rock generally fresh, joints stained, and discoloration extends into rock up to 1 in. Joints may contain clay. In granitoid rocks some occasional feldspar crystals are dull and discolored. Crystalline rocks ring under hammer. Significant portions of rock show discoloration and weathering effects. In granitoid rocks, most feldspars are dull and discolored; some show clayey. Rock has dull sound under hammer and shows significant loss of strength as compared with fresh rock.
Moderate	All rock except quartz discolored or stained. In granitoid rocks, all feldspars dull and discolored and majority show kaolinization. Rock shows severe loss of strength and can be excavated with geologist's pick.
Moderately severe	All rock except quartz discolored or stained. Rock "fabric" clear and evident, but reduced in strength to strong soil. In granitoid rocks, all feldspars kaolinized to some extent. Some fragments of strong rock usually left.
Severe	All rock except quartz discolored or stained. Rock "fabric" discernible, but mass effectively reduced to "soil" with only fragments of strong rock remaining.
Very severe	Rock reduced to "soil". Rock "fabric" no discernible or discernible only in small, scattered locations. Quartz may be present as dikes or stringers.
Complete	

HARDNESS (for engineering description of rock – not to be confused with Moh's scale for minerals)

Very hard	Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows of geologist's pick.
Hard	Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen.
Moderately hard	Can be scratched with knife or pick. Gouges or grooves to ¼ in. deep can be excavated by hard blow of point of a geologist's pick. Hand specimens can be detached by moderate blow.
Medium	Can be grooved or gouged 1/16 in. deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1-in. maximum size by hard blows of the point of a geologist's pick.
Soft	Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure.
Very soft	Can be carved with knife. Can be excavated readily with point of pick. Pieces 1-in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail.

Joint, Bedding, and Foliation Spacing in Rock ¹

Spacing	Joints	Bedding/Foliation
Less than 2 in.	Very close	Very thin
2 in. – 1 ft.	Close	Thin
1 ft. – 3 ft.	Moderately close	Medium
3 ft. – 10 ft.	Wide	Thick
More than 10 ft.	Very wide	Very thick

1. Spacing refers to the distance normal to the planes, of the described feature, which are parallel to each other or nearly so.

Rock Quality Designator (RQD) ¹

RQD, as a percentage	Diagnostic description
Exceeding 90	Excellent
90 – 75	Good
75 – 50	Fair
50 – 25	Poor
Less than 25	Very poor

1. RQD (given as a percentage) = length of core in pieces 4 inches and longer / length of run

Joint Openness Descriptors

Openness	Descriptor
No Visible Separation	Tight
Less than 1/32 in.	Slightly Open
1/32 to 1/8 in.	Moderately Open
1/8 to 3/8 in.	Open
3/8 in. to 0.1 ft.	Moderately Wide
Greater than 0.1 ft.	Wide

References: American Society of Civil Engineers. Manuals and Reports on Engineering Practice - No. 56. Subsurface Investigation for Design and Construction of Foundations of Buildings. New York: American Society of Civil Engineers, 1976. U.S. Department of the Interior, Bureau of Reclamation, Engineering Geology Field Manual.