Report of Geotechnical Exploration Program

Proposed Truck Scales
Lakota, North Dakota
ZGE #14-088

For

CHS - LAKE REGION GRAIN

December 3, 2014

Zeltinger Geotechnical Engineering
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Report of geotechnical exploration program
Zeltinger Geotechnical Engineering

Zeltinger Geotechnical Engineering, P.C.

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December 3, 2014

CHS - CHS Lake Region Grain
Attn: Mr. Mark Greicar
P.O. Box 782
3719 14th Street NW
Devils Lake, ND 58301

Subj: **Geotechnical Exploration Program**
Proposed Truck Scales
Lakota, North Dakota
ZGE #14-088

Dear Mr. Greicar:

Attached is the report covering the geotechnical exploration program that we conducted for the proposed truck scales at Lakota. We are sending the report as an electronic file in pdf format. If you require an original hard copy please contact us. An additional copy is being sent as noted below. This work was conducted in accordance with our quotation 2014-179 dated October 23, 2014 and your signature of authorization of the same date.

We will retain about 50 percent of the soil samples in our office for a period of about 1 month. They will then be discarded unless we are notified in writing to hold them for a longer period of time.

We appreciate the opportunity to be of service to you on this project. If there are questions about the data or our recommendations, please contact me at (701) 255-2371. Also please contact us when you are ready for excavation and compaction tests of the controlled fill.

Very truly yours,

Joel A. Zeltinger

Joel A. Zeltinger, P.E.
Geotechnical Consultant

JAZ/jaz

PC: CHS Country Operations, Attn: Mr. Jim Gales, Mr. Tim Hoare & Mr. Ryan Chermak

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Lakota, North Dakota
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GEOTECHNICAL EXPLORATION PROGRAM
PROPOSED TRUCK SCALES
LAKOTA, NORTH DAKOTA
ZGE #14-088

1 INTRODUCTION

1.1 Authorization

This work was conducted in accordance with our quotation 2014-179 dated October 23, 2014 and the signature of Mr. Mark Greicar with CHS on the same date.

1.2 Scope of Services

The authorized scope of services included soil borings, laboratory testing and an engineering report.

The authorized drilling included one boring to a depth of 21 feet and one to 31 feet at each of the two proposed truck scales. Soil sampling was conducted using standard penetration (SPT) procedures. Undisturbed samples of soft cohesive soil were also obtained using 3-inch thin walled Shelby tubes.

Laboratory tests authorized included moisture content, dry density, Atterberg limits (liquid & plastic limits) and unconfined compression testing.

The authorized engineering report includes the results of the field and laboratory testing as well as engineering recommendations regarding:

a. Soil and groundwater conditions

b. Foundation types and depths, allowable bearing capacities and estimated potential foundation settlement

c. Placement of controlled, compacted backfill

d. Potential construction difficulties such as high groundwater

e. Potentially expansive or compressible soils

f. Lateral earth pressures

g. Site drainage

Pavement design and a determination of whether or not environmental contamination is present was not included in the scope of services.

2 ENGINEERING REVIEW

2.1 Project Data

If the project information presented below is not correct or has been changed, it is necessary that the correct project data be presented to us for further review.

Two above ground truck scales are proposed, designated in this report as the inbound (east) scale and the outbound (west) scale. Please note the attached site plan for the scale and boring locations. We assume that both scales will be about 16 feet wide and 117 feet in length. We also presume that a standard pad and pier foundation carried to frost depth is planned. According to the notes on the site plan the pad and pier foundation system requires a net allowable soil bearing capacity of 1500 psf. The indicated maximum allowable total and differential settlements were indicated as being 3 and 1½ inches, respectively.

We presume that the sites will require some minor amounts of cut and fill to attain the final grade elevation. For the purpose of this report, we assumed that the final grades will be within 2 feet of the ground elevation that was present when the borings were drilled.

2.2 General Overview

Some fill and/or topsoil were encountered at both scale locations. They should not be relied on to support footings or approach slabs. The natural soils were then fairly competent at the inbound scale; however, some softer clays were encountered at the east end of the outbound scale. If the allowable soil bearing capacity and settlement of the soils are acceptable, it is our opinion that deep foundations or specialized soil improvement techniques would not be necessary.

Some groundwater could cause construction difficulties, primarily at the outbound scale. However, it appears that surface sumps should be capable of handling the groundwater.

2.3 Site Preparation

We presume that site preparation will simply consist of cutting or filling to the desired lines and grades before foundation excavation is performed.

2.4 Foundation Recommendations

2.4.1 Frost Depth

We recommend a minimum embedment depth of 7 feet from final grade to the bottom of the footings since the scales will be in an unheated environment.

2.4.2 Footing Excavations

We recommend that footing excavation be performed with a backhoe that has a smooth cutting edge on the bucket. Also, since the soils may be easily disturbed during the placement of forms and reinforcing steel, it would be prudent to place a 2 to 3 inch working surface consisting of lean concrete or CDF (controlled density fill sometimes called flowable fill) to minimize disturbance. However, if in the opinion of the contractor the soils are not easily disturbed the working surface could be omitted. If CDF is used it should have a minimum compressive strength of 150 psi.

If groundwater enters the excavations, which we expect it will, surface sump pumps should control the groundwater. Also, either CDF should be used as backfill below the footings or controlled, compacted granular fill should be used. If CDF is used a convenient lateral excavation oversize should be provided. If controlled, compacted fill is used provide a lateral excavation oversize of 1 foot for each foot of fill required below the footings.

If compacted fill is used below the footings instead of CDF, and groundwater enters the excavation, we recommend using a layer of free draining rock fully encapsulated in a geotextile filter fabric such as Mirafi 180N or equivalent. The rock layer should probably be about 12 inches thick and will be used to control the groundwater during the rest of the fill placement and provide

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a working surface. If no water enters the excavations then the rock and fabric would not be required.

Groundwater should be pumped from the rock until the backfill has been placed to a point above the groundwater level and the footings have been placed. Controlled, compacted fill placed above the rock layer could consist of a pit-run sand and gravel. It should be placed in maximum lift thicknesses of 12 inches and compacted to at least 98 percent of the standard Proctor density.

If earthwork is done during periods of freezing temperatures, we recommend protecting the fill from freezing once it has been placed. No frozen soils should be used as fill and fill should not be placed on frozen ground. Please note the information sheet "Precautions for Excavating and Refilling During Cold Weather" in Appendix C.

2.4.3 Bearing Capacity and Settlement

As mentioned, the existing fill and topsoil should not be relied upon to support the scale foundations or any approach slabs. It is our opinion that the natural undisturbed soils at the recommended frost depth have a net allowable soil bearing capacity of up to 3000 psf at the inbound scale (Borings 1 and 2) and 2000 psf at the outbound scale (Borings 3 and 4). The theoretical safety factor with respect to a shear failure on the order of 3.0 or more. Total and differential settlement at the inbound scale should not exceed 1 and ½ inches, respectively. However, at the outbound scale settlements could be a concern.

Using a bearing capacity of 2000 psf for the outbound scale it is our opinion that total settlement at Boring 3 would only be about ½ to 1 inch. At Boring 4 it could be as much as 1 to 1½ inches. Therefore, the differential settlement could be up to 1 inch between the two borings. If the loading was reduced to 1500 psf it appears that the total settlement would be about 1 inch and differential settlement could be about ¾ inches.

If the total and differential settlements at the outbound scale are more than acceptable, or if a higher bearing capacity is required, we recommend that the foundations be subcut to a depth of 11.5 feet and then re filled with CDF or controlled, compacted fill as previously recommended. Then a net allowable soil bearing capacity of up to 4000 psf could be used and total and differential settlements should be less than 1 and ½ inch, respectively.

2.4.4 Methods of Analyses

The allowable foundation loadings recommended were arrived at using the Terzaghi-Meyerhof bearing capacity equation with the cohesion determined from the unconfined compression testing. The angle of internal friction of cohesionless soils and granular fill was estimated based on our experience.

Settlements were estimated using empirical correlations with the "N" value and the pressuremeter modulus, with consideration given to soil type. The pressuremeter method of analysis was then used.

2.4.5 Lateral

If fill next to the foundations is used to resist lateral loads, it should be compacted to at least 95 percent of the standard Proctor density.

The passive pressure can be calculated from the ground surface to develop the passive pressure envelope. However, due to the potential for frost softening, we recommend neglecting any passive pressure for portions of the foundation system in the upper 5 feet in unheated areas. It should also be neglected to the depth of the existing fill and topsoil, which was 5 to 6 feet.

With the high groundwater, we recommend using an ultimate effective passive pressure equivalent to that generated by a fluid having a total unit weight of 150 pcf for the natural or compacted lean clays. For compacted granular fill a value of 210 pcf can be used as long as the granular fill extends past the edge of the footings at least twice the depth of the footing.

If required, the ultimate friction factor between the bottom of the footings and the underlying soils can be taken as 0.30.

The recommended friction factor and the values for passive pressure will give the ultimate resistance to lateral loads. We recommend that a theoretical safety factor of 2.0 or more be applied.

2.5 Foundation Backfill and Surface Drainage

Exterior foundation backfill could consist of sand or clay. However, if sand is used, we recommend the placement of a clay cap that is at least 18 inches thick to divert surface water away from the scales. Clayey soils should be placed at a moisture content from -2 to +3 percent of the optimum moisture content. Therefore, an area may be required to facilitate moisture conditioning of the clay to the desired moisture content.

We recommend that exterior backfill around the scales in areas not resisting lateral loads be compacted to at least 92 percent of the standard Proctor density in lawn or non structural areas. Any perimeter backfill that will support driveways or other structures should be

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compacted to at least 95 percent of the standard Proctor density and the moisture content of clays should be 0 to 3 percent over optimum.

Surface water should not be allowed to pond near the scales. Also, if there is any water pumped from below the scales, it should be directed a significant distance from the scales to minimize frost action of saturated soils.

3 CONSTRUCTION OBSERVATION AND TESTING

The recommendations contained in this report have been made based on the subsurface conditions found at the boring locations. It is possible that there are soil conditions on site that were not represented by those borings. Also, in order to use shallow foundations on the soils at this site, we presume that close construction monitoring during excavation and backfilling would be authorized. Consequently, on-site observation during construction is considered integral to the successful implementation of the recommendations.

It is imperative that the geotechnical engineer, or his representative, be on site at the following times to observe the site conditions and effectiveness of the construction. We recommend that the testing be performed by the geotechnical engineer as the **owners** representative during construction.

3.1 Excavation Observations

We recommend that the Geotechnical Engineer of record observe all excavations prior to the placement of controlled, compacted engineered fill. He would also be available for additional consultation and recommendations if necessary.

3.2 Placement of Fill

It will also be necessary to perform a representative number of compaction tests during placement of engineered fill. The tests should be performed to determine if the required compaction was achieved. As a general guideline, tests should be taken for each 2,000 square feet of embankment fill, every 75 to 100 feet in trench fill, and for each 2 foot thickness of fill. The actual number of tests should be left to the discretion of the geotechnical engineer.

4 EXPLORATION LIMITATIONS

The recommendations contained in this report represent our professional opinions. These opinions were arrived at according to currently accepted engineering practices at this time and location. Other than this, no warranty is intended or implied.

This report was written by:

JOEL A. ZELTINGER
REGISTERED
PROFESSIONAL
PE-2612
ENGINEER
NORTH DAKOTA

Joel A. Zeltinger, P.E.
Geotechnical Engineer

APPENDIX A - FIELD EXPLORATION PROGRAM

Attachments to Appendix A

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A FIELD EXPLORATION PROGRAM

A.1 Exploration Scope

One boring was drilled to a depth of 21 feet and another was drilled to 31 feet at each of the two truck scales on November 17, 2014. The ground elevations at the test boring locations were referenced to the top of the south railroad track of the southern most set of tracks. The track was assumed to be at an elevation of 100.0 feet.

The borings were backfilled with on-site materials and some settlement of these materials can be expected to occur. Final closure of the holes is the responsibility of the client or property owner.

A.2 Surface Observations

Borings 1 and 2 were drilled for the inbound scale and Borings 3 and 4 were drilled for the outbound scale, as shown on the attached site plan. The site for the inbound scale was in a ditch on the north side of 1st Avenue and west of the scale house and the outbound scale was on a gravel road southeast of the scale house and south of 1st Avenue. Grade elevations at the test boring locations ranged from 97.9 to 98.3 feet at the inbound scale and 97.4 to 97.6 at the outbound scale.

A.3 Subsurface Conditions

The subsurface conditions encountered at each test location are illustrated by means of the attached boring logs. We wish to point out that the subsurface conditions at other times and locations at the site may differ from those found at our test boring locations. If different conditions are encountered during construction, it is necessary that you contact us so that our recommendations can be reviewed. The test boring logs also show the possible geologic origin of the materials encountered.

All of the borings encountered either some fill or topsoil at the surface. At the inbound scale 2 to 5 feet of fill consisting of dark brown fine grained silty sand fill with a trace of gravel and some clay layers was encountered. At the outbound scale the west boring encountered 5 feet of sand and clay fill and the east boring encountered 2 feet of silty sand fill. The east boring also encountered 4 feet of topsoil below the fill.

Natural soils below the fills and topsoil then consisted predominantly of sandy lean clay with a trace of gravel. It was brown to gray and mottled. It contained a trace of gravel as well. At the east end of the outbound scale lean clay with no gravel extended from 6 to 11.5 feet and then the sandy lean clay was encountered. The sandy lean clay extended to the depths of the borings except the west end of the outbound scale where shale was encountered at 28 feet.

Based on the standard penetration resistance ("N" values), the clays were soft to about 6.5 feet at the inbound scale and then firm in consistency. At the outbound scale the clays were soft to 6.5 feet at the west boring but 11.5 feet at the east boring. The clays were then firm in consistency, as was the shale.

A.4 Water Levels

Groundwater level measurements were made in the borings. This information is shown on the bottom of the attached boring logs. The highest measurable water at the inbound scale was 17 feet and at the outbound scale it was 5.5 feet. Based on our experience at the fertilizer building we would recommend assuming that the general groundwater in this area is about 5 feet below grade.

Water level checks in relatively impervious clays, such as encountered at this site, generally require a large amount of observation time to accurately establish the static water level. Long term water level monitoring was not included in the scope of services. Also, seasonal and yearly fluctuations in water levels can be expected. Therefore, the water level at the time of construction could be significantly different than that noted in the borings.

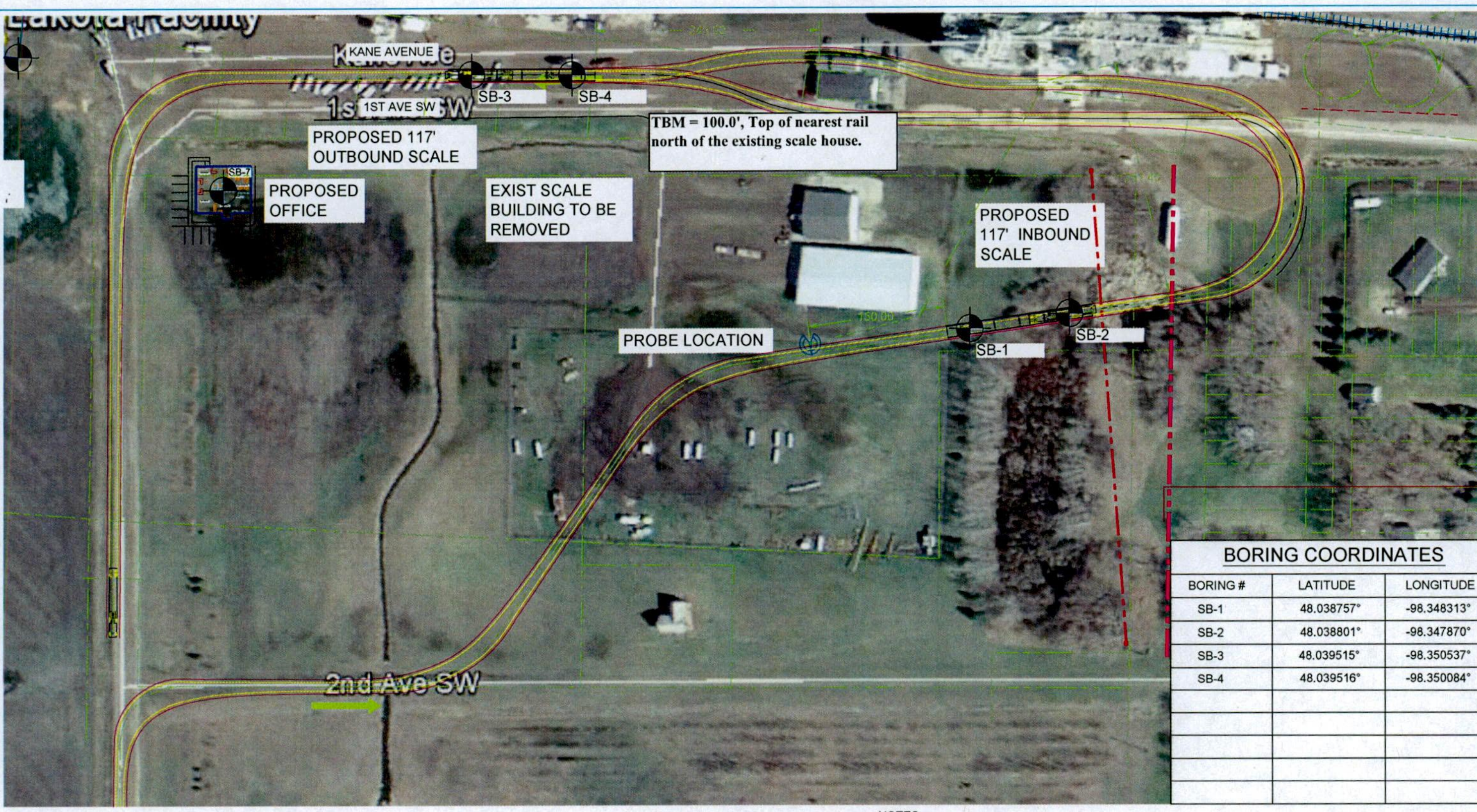
A.5 Soil Sampling

Soil sampling was done according to the procedures described by ASTM D1586. Using this procedure, a 2 inch O.D. split barrel sampler is driven into the soil by a 140-lb weight falling 30 inches. After an initial set of 6 inches, the number of blows required to drive the sampler an additional 12 inches is known as penetration resistance or "N" value. The "N" value is an index of the relative density of cohesionless soils and the consistency of cohesive soils. Some 3-inch thin walled Shelby tube samples were also taken of soft cohesive soil for laboratory testing.

We are retaining representative samples of the soil obtained during our field operations for one month. We will then discard them unless we are notified further as to their disposition.

A.6 Soil Classification Procedure

As the samples were obtained in the field they were visually and manually classified by the crew chief according to ASTM D 2488. Representative portions of all samples were then sealed and returned to the laboratory for further examination and for verification of the field classification. In addition, selected samples were then submitted to a program of laboratory tests. Logs of the borings indicating the depth and identification of the various strata, the "N" value, the laboratory test data, water level information and pertinent information regarding the method of maintaining and advancing the drill holes are also attached. Charts illustrating the soil classification procedures, the descriptive terminology and symbols used on the boring logs are also attached.



BORING COORDINATES

BORING #	LATITUDE	LONGITUDE
SB-1	48.038757°	-98.348313°
SB-2	48.038801°	-98.347870°
SB-3	48.039515°	-98.350537°
SB-4	48.039516°	-98.350084°

NORTH

1 EX2 **SOIL BORING EXHIBIT**

1=100'

0 100' 200' 300'

LEGEND

SB-3 PROPOSED SOIL BORING LOCATION

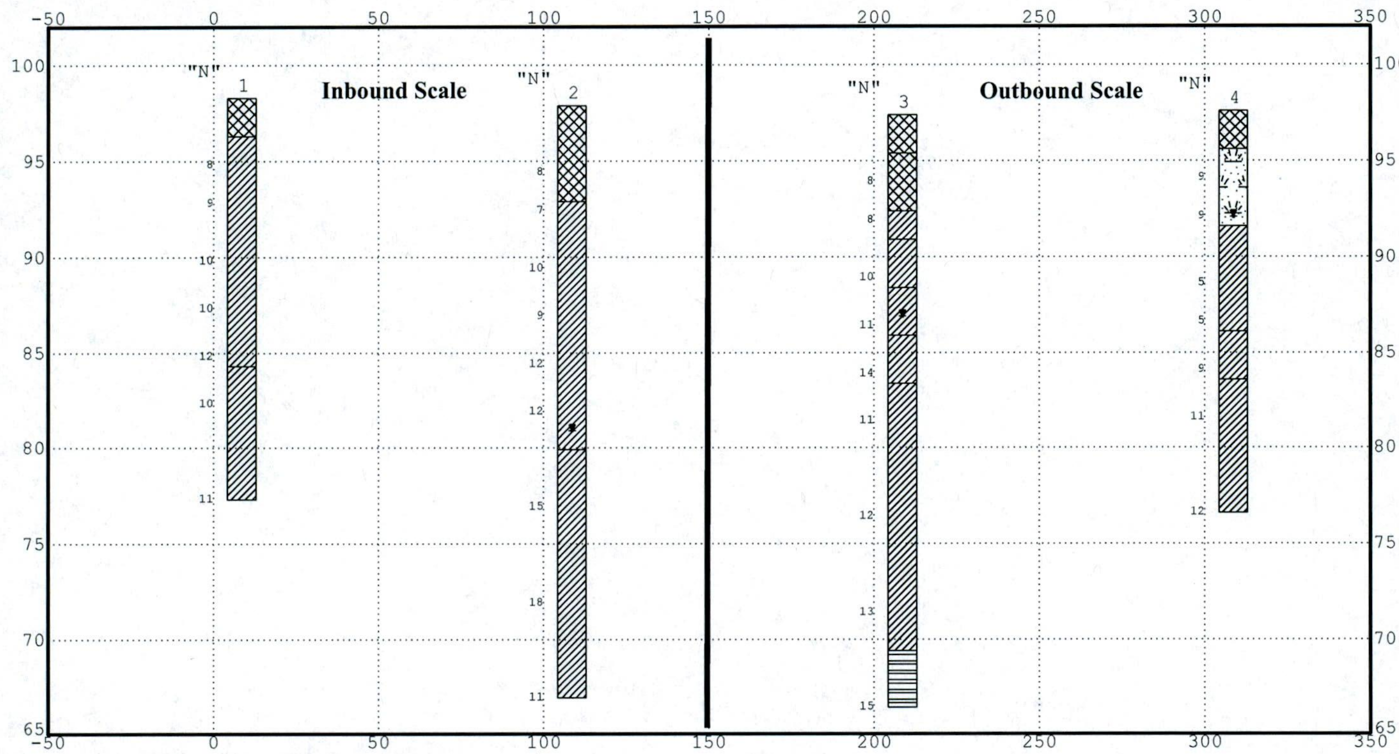
NOTES:

1. 1,500 PSF UNDER SCALE.
2. 3" TOTAL SETTLEMENT, 1½" DIFFERENTIAL SETTLEMENT MAX.
3. FINAL BORING DEPTH TO BE DETERMINED BY GEOTECH.

SOIL BORING EXHIBIT
SCALE AND PROBE - LAKOTA, ND

CHS

PROJECT: XXXXXX
10-21-2014



Boring	North	East	Elev.	Depth
1	100.0	100.0	98.3	21.0
2	100.0	200.0	97.9	31.0
3	100.0	300.0	97.4	31.0
4	100.0	400.0	97.6	21.0

COORDINATES ARE ASSUMED
DISTANCES:
Beginning -50.0
Ending 350.0
VIEWING ANGLES (degrees):
Horizontal 0.0
Vertical 0.0

Position	North	East
Left, Front	100.00	50.00
Right, Front	100.00	450.00
Left, Back	100.00	50.00
Right, Back	100.00	450.00

SOIL PROFILE DIAGRAM

Truck Scales

Lakota, ND

PROJECT #	DATE	PLATE
ZGE #14-088	Dec 14	1

LOG OF TEST BORING

JOB NO. **ZGE #14-088** VERTICAL SCALE **1" = 5'** BORING NO. **1**

PROJECT **Truck Scales, Lakota, ND**

SURFACE ELEVATION **98.3**

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE NO.	SAMPLE TYPE	W	D	LL	PL	QU or RQD
	FILL, mostly SILTY SAND, fine grained, a trace of gravel, dark brown, moist	Fill			1	HSA					
2.0	**SANDY LEAN CLAY**, a trace of gravel, brown, mottled, soft to firm (CL)	Glacial Till	8		2	SB					
			9		3	SB					
			10		4	SB					
			10		5	SB					
			12		6	SB					
14.0	**SANDY LEAN CLAY**, a trace of gravel, gray, firm (CL)		10		7	SB					
			11		8	SB					
21.0	End of Boring										

* None Measurable

Drilled on Road

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
11-17	1250	21'	None	14'		*NM

START **11-17-14** COMPLETE **11-17-14** @ **1005**

METHOD **3.25" I.D. HSA 0' to 19.5'**

CREW CHIEF **JZ (IDS)**

ZELTINGER GEOTECHNICAL ENGINEERING, P.C.

LOG OF TEST BORING

JOB NO. ZGE #14-088 VERTICAL SCALE 1" = 5' BORING NO. 2

PROJECT Truck Scales, Lakota, ND

SURFACE ELEVATION 97.9

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE NO.	SAMPLE TYPE	W	D	LL	PL	QU or RQD
	FILL, mostly SILTY SAND, fine grained, a trace of gravel, dark brown, moist, layer of geogrid at 4', clay layers below 4'	Fill			1	HSA					
			8		2	SB					
5.0			7		3	SB					
	SANDY LEAN CLAY, a trace of gravel, brown, mottled, soft to firm (CL)	Glacial Till									
			10		4	SB					
					5	3T					
	3T sample taken at 9' to 11' from secondary boring.		9		6	SB					
			12		7	SB					
			12		8	SB					
				▼							
18.0	**SANDY LEAN CLAY**, a trace of gravel, gray, firm to hard (CL)										
			15		9	SB					
			18		10	SB					
			11		11	SB					
31.0	End of Boring										
	Drilled on Road										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
11-17	1244	31'	None	20.5'		17'

START 11-17-14 COMPLETE 11-17-14 @ 0925

METHOD 3.25" I.D. HSA 0' to 29.5'

CREW CHIEF JZ (IDS)

ZELTINGER GEOTECHNICAL ENGINEERING, P.C.

LOG OF TEST BORING

JOB NO. **ZGE #14-088** VERTICAL SCALE **1" = 5'** BORING NO. **3**

PROJECT **Truck Scales, Lakota, ND**

SURFACE ELEVATION **97.4**

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE NO.	SAMPLE TYPE	W	D	LL	PL	QU or RQD
2.0	**FILL, mostly SILTY SAND**, fine grained, a trace of gravel, dark brown, moist	Fill			1	HSA					
5.0	**FILL, Mixture of TOPSOIL and FAT CLAY**, black and gray mixed		8		2	SB					
6.5	**SANDY LEAN CLAY**, a trace of gravel, light gray, mottled, soft (CL)	Glacial Till	8		3	SB					
9.0	**SANDY LEAN CLAY**, a trace of gravel, grayish brown, mottled, firm (CL)		10		4	SB					
11.5	**SANDY LEAN CLAY**, a trace of gravel, brown, mottled, firm (CL)		11	▼	5	SB					
14.0	**SANDY LEAN CLAY**, a trace of gravel, grayish brown, mottled, firm (CL)		14		6	SB					
28.0	**SANDY LEAN CLAY**, a trace of gravel, gray, firm (CL) ***Drilled in Ditch***		11		7	SB					
			12		8	SB					
			13		9	SB					
31.0	**SHALE**, highly weathered, gray, firm (Textural Classification: Fat Clay (CH))	Sentinel Butte Formation	15		10	SB					
	End of Boring * None Measurable										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
11-17	1236	31'	None	12'		10.5'

START **11-17-14** COMPLETE **11-17-14** @ **1108**

METHOD **3.25" I.D. HSA 0' to 29.5'**

CREW CHIEF **JZ (IDS)**

ZELTINGER GEOTECHNICAL ENGINEERING, P.C.

LOG OF TEST BORING

JOB NO. ZGE #14-088 VERTICAL SCALE 1" = 5' BORING NO. 4

PROJECT Truck Scales, Lakota, ND

SURFACE ELEVATION 97.6

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE NO.	SAMPLE TYPE	W	D	LL	PL	QU or RQD
2.0	**FILL, mostly SILTY SAND**, fine grained, a trace of gravel, dark brown, moist	Fill			1	HSA					
6.0	**TOPSOIL, ORGANIC LEAN CLAY**, black, firm, highly organic (OL)	Topsoil	9		2	SB					
			9	▼	3	SB					
11.5	**LEAN CLAY**, light grayish brown, mottled, soft (CL) 3T samples taken at 7' to 9' & 9' to 11' from secondary boring.	Fine Alluvium			4	3T	19	106	38	17	2511
			5		5	SB					
					6	3T	20	107	33	18	4513
			5		7	SB					
14.0	**SANDY LEAN CLAY**, a trace of gravel, grayish brown, mottled, firm (CL)	Glacial Till	9		8	SB					
21.0	**SANDY LEAN CLAY**, a trace of gravel, gray, firm (CL)		11		9	SB					
			12		10	SB					

End of Boring

Drilled in Ditch

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
11-17	1120	8.5'	7'	--		7'
11-17	1225	21'	None	11'		5.5'

START 11-17-14 COMPLETE 11-17-14 @ 1138

METHOD 3.25" I.D. HSA 0' to 19.5'

CREW CHIEF JZ (IDS)

ZELTINGER GEOTECHNICAL ENGINEERING, P.C.

SYMBOLS AND DESCRIPTIVE TERMINOLOGY ON TEST BORING LOG

SYMBOLS FOR DRILLING AND SAMPLING

Symbol	Description
HSA	3 1/4" I.D. hollow stem auger
_FA	4", 6" or 10" diameter flight auger
_HA	2", 4" or 6" hand auger
_DC	2 1/2", 4", 5" or 6" steel drive casing
_RC	Size A, B or N rotary casing
PD	Pipe drill or cleanout tube
CS	Continuous split barrel sampling
DM	Drilling mud
JW	Jetting water
SB	2" O.D. split barrel sampling
_L	2 1/2" or 3 1/2" O.D. SB liner sample
_T	2" or 3" thin walled tube sample
3TP	3" thin walled tube using pitcher sampler
_TO	2" or 3" thin walled tube using Osterberg sampler
W	Wash sample
B	Bag sample
P	Test pit sample
_Q	BQ, NQ, or PQ wireline system
_X	AX, BX, or NX double tube barrel
N	Standard penetration test, blows per foot
CR	Core recovery, percent
WL	Water level
••	Water level
NMR	No measurement recorded, primarily due to presence of drilling or coring fluid

SYMBOLS FOR LABORATORY TESTS

Symbol	Description
W	Water content
D	Dry density - pounds per cubic foot
LL	Liquid limit - ASTM** D 4318
PL	Plastic limit - ASTM D 4318
	--- Inserts in Last Column (Qu or RQD) ---
Qu	Unconfined compressive strength, psf - ASTM D 2166
Pq	Penetrometer reading, tsf
Ts	Torvane reading, tsf
G	Specific gravity
SL	Shrinkage limits - ASTM D 427
OC	Organic content - Combustion method
SP	Swell pressure, tsf
PS	Percent swell under pressure
FS	Free swell, percent
SS	Shrink swell, percent
pH	Hydrogen ion content - Meter Method
SC	Sulfate content, parts/million or mg/l
CC	Chloride content, parts/million or mg/l
C*	One dimensional consolidation - ASTM D 2435
Qc*	Triaxial compression
D.S.*	Direct shear - ASTM D 3080
K*	Coefficient of permeability, cm/sec
DH*	Double hydrometer - ASTM D 4221
MA*	Particle size analysis - ASTM D 422
R	Laboratory electrical resistivity, ohm-cm - ASTM G 57
E*	Pressuremeter deformation modulus, tsf
PM*	Pressuremeter test
VS*	Field vane shear - ASTM D 2573
IR*	Infiltrometer test - ASTM D 3385
RQD	Rock quality designation, percent
*	Results shown on attached data sheet or graph
**	ASTM designates American Society for Testing and Materials

DESCRIPTIONS OF N-VALUES VS. SOIL PROPERTIES

N Value	Density
0 - 4	Very loose
5 - 10	Loose
11 - 30	Medium dense
31 - 50	Dense
Over 50	Very dense

N Value	Consistency
0 - 4	Very soft
5 - 8	Soft
9 - 15	Firm
16 - 30	Hard
Over 30	Very hard

DESCRIPTIONS OF SOIL CONDITIONS

Condition	Description
Lamination	Up to 1/2" thick stratum
Layer	1/2" to 6" thick stratum
Dry	Powdery, no noticeable water
Moist	Below saturation
Wet	Saturated, above liquid limit
Waterbearing	Pervious soil below water
Varved	Alternating laminations of any combinations of clay, silt and fine grained sand

DESCRIPTIONS OF GRAVEL PROPORTIONS IN SOILS

Soil Type	Description	Range, %
Coarse grained soils	A little gravel	2 - 14
Coarse grained soils	With gravel	15 - 49
Fine grained soils:		
71-85% passing #200 sieve	A little gravel	2 - 7
71-85% passing #200 sieve	With gravel	8 - 29
70% passing #200 sieve	A little gravel	2 - 14
70% passing #200 sieve	With gravel	15 - 24
70% passing #200 sieve	Gravelly	16 - 49

DESCRIPTIONS OF PARTICLE SIZES

Material Type	Size
Boulders	Over 12"
Cobbles	3" - 12"
Coarse gravel	3/4" - 3"
Fine gravel	#4 sieve - 3/4"
Coarse sand	#4 - #10 sieve
Medium sand	#10 - #40 sieve
Fine sand	#40 - #200 sieve
Silt	100% passing #200 sieve and > 0.002mm
Clay	100% passing #200 sieve and < 0.002mm

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

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APPENDIX B - LABORATORY TEST PROGRAM

B.1 Testing Scope
B.2 Index Properties
B.3 Strength Testing

Attachments to Appendix B
Unconfined Compression Test Results

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B LABORATORY TEST RESULTS

B .1 Testing Scope

Laboratory testing was conducted to characterize soil properties including Atterberg limits (liquid and plastic limits) moisture content and dry density. Strength testing consisted of unconfined compression (QU) testing.

B .2 Index Properties

Testing and classification of soils was performed according to the Unified Soil Classification System as described in ASTM D 2487. Index property tests were performed to aid in soil classification.

Atterberg limits were performed according to ASTM D 4318. Moisture content was determined according to ASTM D 4959 and D 4643. The dry density was determined using direct measurement procedures. The results can be noted on the attached boring logs across from their sample locations.

B .3 Strength Testing

The QU tests were conducted in accordance with ASTM D 2166. The test curves and results are attached at the back of this Appendix.

APPENDIX C

Precautions for Excavating & Refilling During Cold Weather

PRECAUTIONS FOR EXCAVATING AND REFILLING DURING COLD WEATHER

The winter season in North Dakota and Minnesota presents specific problems for foundation construction. Soils which are allowed to freeze undergo a moisture volume expansion, resulting in a loss of density. These frost-expanded soils will consolidate upon thawing, causing settlement of any structure supported on them. To prevent this settlement, frost should not be allowed to penetrate into the soils below any proposed structure.

Ideally, winter excavation should be limited to areas small enough to be refilled to a grade higher than footing grade on the same day. Typically, these areas should be filled to floor grade. Trenching back down to unfrozen soils for foundation construction can then be performed just prior to footing placement. The excavated trenches should be protected from freezing by means of insulating or heating during foundation construction. Backfilling of the foundation trenches should be performed immediately after the below-grade foundation construction is finished. In addition, any interior footings, or footings designed without frost protection should be extended below frost depth, unless adequate precautions are taken to prevent frost intrusion until the building can be enclosed and heated.

In many cases, final grade cannot be attained in one day's time, even though small areas are worked. In the event final grade cannot be attained in one day's time, frost can be expected to develop overnight. The depth of frost penetration can be minimized by leaving a layer of loose soil on top of the compacted material overnight. However, any frost which forms in this loose layer, or snow, should never be used as fill material.

After the structure has been enclosed, all floor slab areas should be subjected to ample periods of heating to allow thawing of the soil system. Alternatively, the frozen soils can be completely removed and be replaced with an engineered fill. The floor slab areas should be checked at random and representative locations for remnant areas of frost, and density tests should be performed to document fill compaction prior to slab placement.

Due to the potential problems associated with fill placement during cold weather, any filling operations should be monitored by a full-time, on-site soils technician. Full-time monitoring aids in detecting areas of frozen material, or potential problems with frozen material within the fill, so that appropriate measures can be taken. The choice of fill material is particularly important during cold weather, since clean granular fill materials can be placed and compacted more efficiently than silty or clayey soils. In addition, greater magnitudes of heaving can be expected with freezing of the more frost susceptible silts and clays.

If more specific frost information, or cold weather data concerning other construction materials is required, please contact us.

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