DYREGROV ROBINSON INC.
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April 6, 2015

File No. 153854

Neil Cooper Architect Inc.
10 – 395 Berry Street
Winnipeg, MB R3J 1N6

Attn: Neil Cooper

Dear Mr. Cooper:

**RE: City of Winnipeg Fleet Garages – 821 Elgin Avenue
Geotechnical Investigation**

As requested, Dyregrov Robinson Inc. (DRI) has undertaken a geotechnical investigation for the proposed renovations to the City of Winnipeg Fleet Garages at 821 Elgin Avenue in Winnipeg, Manitoba. The purpose of the investigation was to evaluate the subsurface conditions in order to provide foundation design recommendations that meet the requirements of the current Manitoba Building Code (i.e. limit states design). The work was authorized by email from Neil Cooper Architect Inc. on February 12, 2015.

1) Proposed Renovations

We understand that the proposed renovations will be located in the north half of the existing building and will include a +/- 120 m^2 extension of the second floor level. Additional foundations will be required for the second floor addition. We understand that the existing building is supported on cast-in-place concrete friction piles.

2) Field Investigation

The geotechnical investigation was initiated on March 4, 2015, which included drilling one test hole on the south side of the building along Elgin Avenue. Shallow auger refusal occurred due to the presence of concrete so it was decided to re-locate the test hole to the east end of the building in the vehicle parking area. The test hole was drilled on March 17, 2015 after clearing the underground utility services for the new test hole location. The test hole was drilled to auger refusal in the glacial till by Subterranean Ltd. using a truck mounted CME 202 drill rig equipped with 125 mm diameter solid stem augers. The test hole was backfilled with auger cuttings and bentonite chips. The asphalt surface was patched with cold mix asphalt.

The subsurface conditions were visually logged during drilling by DRI. Disturbed (auger cuttings) and undisturbed (Shelby tube) samples were recovered from the test hole and taken to our Soils Testing Laboratory for additional visual classification and testing. The laboratory testing consisted of determining moisture contents on all samples and measuring bulk unit weights and undrained shear strengths on the Shelby tube samples. The test hole log is attached and includes a description of the subsurface conditions encountered, results of the laboratory testing, and notes regarding the observations made during drilling.

3) Subsurface Conditions

The soil stratigraphy encountered in the test hole, from site grade, consists of silt, silty clay and glacial till. A 50 mm thick layer of asphalt was encountered at grade; no granular base material was present. The ground was frozen to a depth of 2 m at the time of drilling.

Silt

A layer of silt was encountered below the asphalt. The silt is 1.4 m feet thick, grey and moist (i.e. upon thawing). The moisture content is around 24 percent.

Silty Clay

The usual thick deposit of Lake Agassiz lacustrine silty clay was encountered beneath the silt at a depth of 1.4 m below grade. The clay deposit is about 10.8 m thick. It is mottled brown and grey to a depth of about 7.6 m below which it is grey in color. The clay is moist with a stiff consistency to a depth of 8.5 m, below this depth the clay is wet and firm. The moisture contents of the clay range from about 45 to 60 percent to a depth of 10.5 m, below this depth the moisture content drops off to about 35 percent. The undrained shear strength of the clay was measured using Torvane, penetrometer and unconfined compressive strength tests. The clay has undrained shear strengths ranging from about 30 to 80 kPa. The bulk unit weight of the clay is about 17 kN/m^3.

Silt (Till)

Glacial silt till was encountered in the test hole at a depth of 12.2 m. The till in the Winnipeg area is known to be a heterogeneous mixture of sand, gravel, cobble and boulder size materials in a clay and/or silt matrix. The till encountered in the test hole is a grey silt till containing trace amounts of sand and gravel. The till is wet and loose with a moisture content of 28 percent from one sample. Auger refusal occurred at a depth of 12.8 m, possibly on bedrock.

Test Hole Stability and Groundwater Conditions

Trace amounts of seepage were observed at a depth of 4.6 m. About 10 minutes after drilling the test hole to auger refusal, the test hole was open to a depth of 12.5 m and the water level was 2.1 m below grade. The groundwater conditions should be expected to vary seasonally, from year to year and possibly as a result of construction activities.

4) Foundation Recommendations

The subsurface conditions at this site are suitable for cast-in-place concrete friction piles.

Cast-In-Place Concrete Friction Piles

Cast-in-place concrete friction piles can be designed in accordance to the current Manitoba Building Code (i.e. NBC 2010) using the service limit state (SLS) shaft adhesion values provided in Table 1 below. For the ultimate limit state (ULS) case, the piles can be designed with the factored shaft adhesion values and the factored end bearing pressures provided in Table 1. A resistance factor of 0.4 was used to calculate the factored ULS design values. Under the SLS loads, pile settlements are expected to be around 6 mm inches with differential settlements between piles around 3 to 6 mm.

Table 1: Design Parameters for CIP Concrete Friction Piles

Depth Below Existing Site Grade (m)	SLS Shaft Adhesion (kPa)	Factored ULS Shaft Adhesion (kPa)	Factored ULS End Bearing (kPa)
0 to 2.5 (see Note 1)	0	0	0
2.5 to 7.0	20.0	24.0	145
7.0 to 10.5	13.3	16.0	145

Note 1: *When determining effective pile lengths, the upper 2.5 m of the pile shaft below existing site grade or 1.5 m below basement / crawl space levels, whichever is deeper, should be ignored to account for the presence of fill materials, silt layers and the potential for soil shrinkage away from the pile. If encountered, the presence of backfill may require more than 2.5 m of pile shaft to be ignored. The backfill conditions will not be known until the time of construction.*

The pile length should be limited to 10.5 m below existing site grade to avoid drilling into the glacial till layer which has a very high groundwater pressure. Piles should have a minimum diameter of 406 mm, a minimum length of 6 m and a minimum spacing of 3 pile diameters on centre. This spacing also applies to new piles installed near existing piles. Where this spacing cannot be achieved DRI should be contacted for additional input. Small pile groups (maximum of 4 piles) can be considered for moderately high column loads.

Concrete should be placed as soon as possible after each pile hole is completed. Temporary steel sleeves should be on site and used where sloughing/caving of the pile borings occur and/or if groundwater seepage is encountered.

Piles that are subjected to freezing conditions must be protected from potential frost heave effects by using minimum pile lengths of 7.5 m and installing full length reinforcement. The use of flat lying rigid insulation, such as Styrofoam HI, can also be used to minimize frost penetration into the soil around the piles if the minimum pile length cannot be achieved. A greased, polyethylene wrapped sonotube can be placed around the upper 1.8 m of the pile shaft to act as a bond breaker and provide additional protection against frost heave.

Other

A void separation of at least 150 mm should be provided under grade beams and pile caps. A vapour barrier should be provided below grade beams and pile caps to minimize the potential for long term moisture changes within the underlying clay soils.

The potential for sulphate attack in Winnipeg is considered to be severe. It is recommended that all concrete in contact with clay soil should be manufactured with sulphate-resistant cement in accordance with the Building Code.

5) Closure

This report was prepared based on our understanding of the proposed building renovations at 821 Elgin Avenue and the subsurface conditions encountered in the test hole drilled at the site. Subsurface conditions are inherently variable and should be expected to vary from those encountered in the test hole.

This report was prepared for the exclusive use of Neil Cooper Architect Inc., the City of Winnipeg and their agents for the design of the proposed building renovations at 821 Elgin Avenue in Winnipeg, MB. The information and recommendations contained in this report shall not be used by any third parties for any other projects. The findings and recommendations in this report have been prepared in accordance with generally accepted geotechnical engineering principles and practise. No other warranty, expressed or implied, is provided.

Please contact the undersigned if we can be of further assistance.

DYREGROV ROBINSON INC.

Gil Robinson, M.Sc., P.Eng.
President, Senior Geotechnical Engineer
gilrobinson@drgeotechnical.com

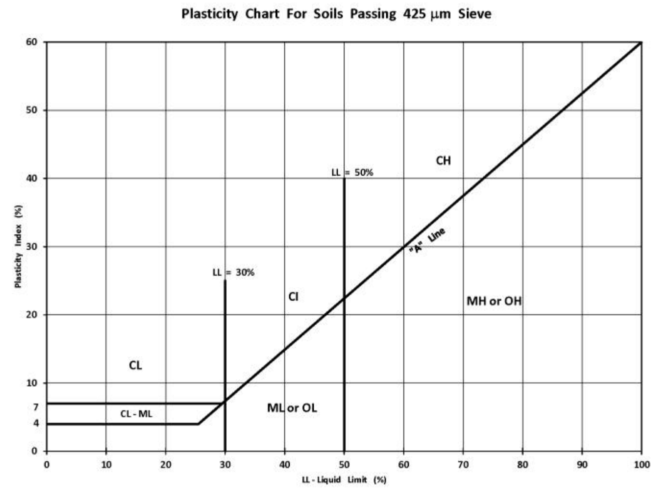
PROVINCE OF MANITOBA
G.G.B.
ROBINSON
6 April 2015
REGISTERED PROFESSIONAL ENGINEER

APEGM
Certificate of Authorization
Dyregrov Robinson Inc.
No. 86 Date: 6 April 2015

EXPLANATION OF TERMS & SYMBOLS

Description				TH Log Symbols	USCS Classification	Laboratory Classification Criteria			
						Fines (%)	Grading	Plasticity	Notes
COARSE GRAINED SOILS	GRAVELS (More than 50% of coarse fraction of gravel size)	CLEAN GRAVELS (Little or no fines)	Well graded gravels, sandy gravels, with little or no fines		GW	0-5	$C_U > 4$ $1 < C_C < 3$		Dual symbols if 5-12% fines. Dual symbols if above "A" line and 4<W_P<7 $C_U = \frac{D_{60}}{D_{10}}$ $C_C = \frac{(D_{30})^2}{D_{10} x D_{60}}$
			Poorly graded gravels, sandy gravels, with little or no fines		GP	0-5	Not satisfying GW requirements		
		DIRTY GRAVELS (With some fines)	Silty gravels, silty sandy gravels		GM	> 12		Atterberg limits below "A" line or W_P<4	
			Clayey gravels, clayey sandy gravels		GC	> 12		Atterberg limits above "A" line or W_P<7	
	SANDS (More than 50% of coarse fraction of sand size)	CLEAN SANDS (Little or no fines)	Well graded sands, gravelly sands, with little or no fines		SW	0-5	$C_U > 6$ $1 < C_C < 3$		
			Poorly graded sands, gravelly sands, with little or no fines		SP	0-5	Not satisfying SW requirements		
		DIRTY SANDS (With some fines)	Silty sands, sand-silt mixtures		SM	> 12		Atterberg limits below "A" line or W_P<4	
			Clayey sands, sand-clay mixtures		SC	> 12		Atterberg limits above "A" line or W_P<7	
FINE GRAINED SOILS	SILTS (Below 'A' line negligible organic content)	W_L<50	Inorganic silts, silty or clayey fine sands, with slight plasticity		ML			Classification is Based upon Plasticity Chart	
		W_L>50	Inorganic silts of high plasticity		MH				
	CLAYS (Above 'A' line negligible organic content)	W_L<30	Inorganic clays, silty clays, sandy clays of low plasticity, lean clays		CL				
		30<W_L<50	Inorganic clays and silty clays of medium plasticity		CI				
		W_L>50	Inorganic clays of high plasticity, fat clays		CH				
	ORGANIC SILTS & CLAYS (Below 'A' line)	W_L<50	Organic silts and organic silty clays of low plasticity		OL				
		W_L>50	Organic clays of high plasticity		OH				
HIGHLY ORGANIC SOILS			Peat and other highly organic soils		Pt	Von Post Classification Limit		Strong colour or odour, and often fibrous texture	

	Asphalt		Glacial Till		Bedrock (Igneous)	
	Concrete		Clay Shale		Bedrock (Limestone)	**DYREGROV ROBINSON INC.** CONSULTING GEOTECHNICAL ENGINEERS
	Fill				Bedrock (Undifferentiated)	



FRACTION		PARTICLE SIZE (mm) Min.	Max.
Boulders		>300	
Cobbles		75	300
Gravel	Coarse	19	75
	Fine	4.75	19
Sand	Coarse	2.0	4.75
	Medium	0.425	2.0
	Fine	0.075	0.425
Silt (non-plastic) or Clay (plastic)		< 0.075 mm	

RELATIVE PROPORTIONS (by weight) Percent	Descriptor
>35%	main fraction
35 - 50	"and"
20 – 35	Adjective e.g. silty, clayey
10 – 20	"some"
1 - 10	"trace"

Soil Classification Example

Clay 50% (main fraction), Silt 25%, Sand 17%, Gravel 8%

Clay – silty, some sand, trace gravel

TERMS and SYMBOLS

Laboratory and field tests are identified as follows:

Unconfined Comp.: undrained shear strength (kPa or psf) derived from unconfined compression testing.

Torvane: undrained shear strength (kPa or psf) measured using a Torvane

Pocket Pen.: undrained shear strength (kPa or psf) measured using a pocket penetrometer.

Unit Weight bulk unit weight of soil or rock (kN/m^3 or pcf).

SPT – N Standard Penetration Test: The number of blows (N) required to drive a 51 mm O.D. split barrel sampler 300 mm into the soil using a 63.5 kg hammer with a free fall drop height of 760 mm.

DCPT Dynamic Cone Penetration Test. The number of blows (N) required to drive a 50 mm diameter cone 300 mm into the soil using a 63.5 kg hammer with a free fall drop height of 760 mm.

M/C insitu soil moisture content in percent

PL Plastic limit, moisture content in percent

LL Liquid limit, moisture content in percent

The undrained shear strength (Su) of cohesive soil is related to its consistency as follows:

Su (kPa)	Su (psf)	CONSISTENCY
<12	250	very soft
12 – 25	250 – 525	soft
25 – 50	525 – 1050	firm
50 – 100	1050 – 2100	stiff
100 – 200	2100 – 4200	very stiff
200	4200	hard

The SPT - N of non-cohesive soil is related to compactness condition as follows:

N – Blows / 300 mm	COMPACTNESS
0 - 4	very loose
4 - 10	loose
10 - 30	compact
30 - 50	dense
50 +	very dense

References:

ASTM D2487 – Classification of Soils For Engineering Purposes (Unified Soil Classification System)

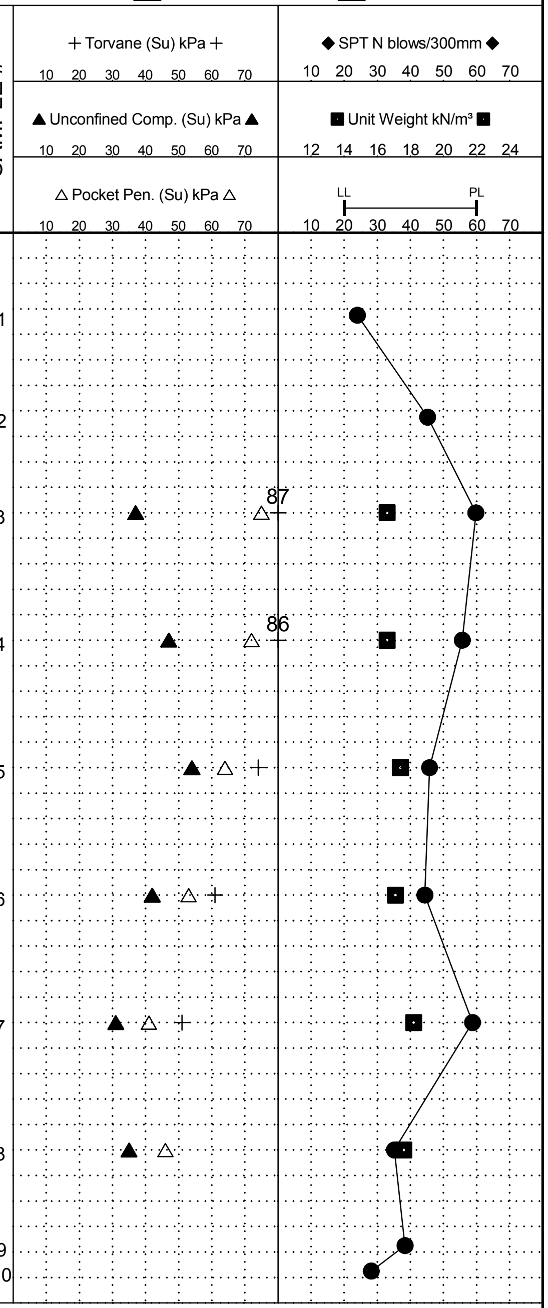
Canadian Foundation Engineering Manual, 4th Edition, Canadian Geotechnical Society, 2006

PROJECT: COW Fleet Garages - 821 Elgin Ave.	CLIENT: Neil Cooper Architect Inc.	TEST HOLE NO: 1
LOCATION: 8 m north and 15 m east from south east corner of 821 Elgin		PROJECT NO.: 153854
CONTRACTOR: Subterranean Ltd.	METHOD: CME 202 Drill, 125 mm diameter SS Augers	ELEVATION (m):

SAMPLE TYPE: GRAB, SHELBY TUBE, SPLIT SPOON, BULK, NO RECOVERY, CORE

BACKFILL TYPE: BENTONITE, GRAVEL, SLOUGH, GROUT, CUTTINGS, SAND

DEPTH (m)	SOIL DESCRIPTION	SAMPLE #
0 – 0.05	ASPHALT - 50 mm thick	
to 1.4	SILT - grey - dry	G1
to 12.3	CLAY - silty - mottled brown and grey - stiff, moist - high plasticity, trace silt inclusions - grey and wet below 7.6 m - trace till inclusions, trace sand, trace gravel - firm below 8.5 m	G2, T3, T4, T5, T6, T7, T8
to 12.8	SILT (Till) - trace sand, trace gravel - grey, loose, wet	G9, G10



END OF TEST HOLE AT 12.8 m IN TILL (AUGER REFUSAL)

Notes:

1. Frost to 2 m.
2. Very slight seepage observed at 4.5 m.
3. Major seepage observed at 12.5 m.
4. Upon completion of drilling, water level at 2.1 m below grade and hole open to 12.5 m.
5. Test hole backfilled with auger cuttings and bentonite chips. Pavement patched with cold mix asphalt.

DYREGROV ROBINSON INC.
Consulting Geotechnical Engineers

LOGGED BY: CR	COMPLETION DEPTH: 12.80 m
REVIEWED BY: GR	COMPLETION DATE: 17/03/15
PROJECT ENGINEER: Gil Robinson	Page 1 of 1