APPENDIX ‘A’

GEOTECHNICAL REPORT

Quality Engineering | Valued Relationships

WSP Canada Group Ltd.

2023 Local and Industrial Streets Renewal Package (23-RI-02)

Prepared for:
Mark Vogt, M.Sc., P.Eng.
WSP Canada Group Ltd.
111-93 Lombard Avenue
Winnipeg, MB
R3B 3B1

Project Number: 1000-043-22

Date: December 16, 2022

TREK
GEOTECHNICAL
Quality Engineering | Valued Relationships

December 16, 2022

Our File No. 1000-043-22

Mark Vogt, M.Sc., P.Eng.
WSP Canada Group Ltd.
111-93 Lombard Avenue
Winnipeg, MB
R3B 3B1

RE: 2023 Local and Industrial Streets Renewal Package (23-RI-02)

TREK Geotechnical Inc. is pleased to submit our Final Report for the geotechnical investigation for 2023 Local and Industrial Streets Renewal Package (23-RI-02) project.

Please contact the undersigned should you have any questions.

Sincerely,

TREK Geotechnical Inc.
Per:

Nelson John Ferreira, Ph.D., P.Eng.
Senior Geotechnical Engineer

Encl.

Revision History

Revision No.	Author	Issue Date	Description
0	AFK	December 16, 2022	Final Report

Authorization Signatures

Prepared By:

Angela Fidler-Kliewer, C.Tech.
Manager of Laboratory and Field Services

N. J. FERREIRA
Member
22892
Dec. 16, 2022

Reviewed By:

Nelson John Ferreira, Ph.D., P.Eng.
Senior Geotechnical Engineer

ENGINEERS
GEOSCIENTISTS
MANITOBA
Certificate of Authorization
TREK GEOTECHNICAL INC.
No. 4877 Date: Dec. 16, 2022

Table of Contents

List of Tables

List of Figures

List of Appendices

1.0 Introduction

This report summarizes the results of the road investigation completed for the Local and Industrial Streets Renewal 23-RI-02 project. The project included drilling test holes and collecting pavement cores along several streets. The test hole information collected describes the pavement structure of the existing road as well as the soil stratigraphy beneath the pavement structure. The investigation was carried out following the City of Winnipeg RFP No. 44-2022 (Appendix B – Site Investigation requirement for public works street projects).

2.0 Road Investigation

The investigation included coring of pavement at 19 locations on 7 different local and Industrial streets with drilling of test holes occurring at 9 of the cored locations along two streets. The investigation locations are shown on Figures 01 to 06 (attached) and the table below summarizes the investigation program per street.

Table 1 – Road Investigation Program

23-RI-02 Pavement and Geotechnical Investigation	# of Locations	Investigation
Panet Rd – Narin Av / CPR Tracks	3	3 test holes to a depths of 2.5 m
Panet Rd – Narin Av / CPR Tracks	2	2 Cores
Panet Rd – Dugald Rd / 45 Panet Rd	3	3 test holes to a depths of 2.5 m
Dugald Rd – Panet Rd / Dawson Rd N	4	4 Cores
Mazenod Rd SB and NB – Dugald Rd / De Baets St	2	4 Cores
Beghin Ave – De Baets St / Paquin Rd	2	4 Cores
Springfield Rd – Lagimodiere Blvd and Cox Blvd	3	3 test holes to a depths of 2.5 m

The road investigation was conducted between November 8, 2022 and November 25, 2022. The pavement structure (asphalt/concrete) was cored by Jashandeep Bhullar of TREK Geotechnical Inc. (TREK) using a portable coring press equipped with a hollow 150 mm diameter diamond core drill bits. The test holes were drilled by Maple Leaf Drilling Ltd to a depth of approximately 3.0 m below road surface using a truck mounted drill rig equipped with 125 mm diameter solid stem augers. The sub-surface conditions were observed during drilling and visually classified by Jashandeep Singh Bhullar of TREK. Other pertinent information such as groundwater and drilling conditions were also recorded during the drilling investigation. Disturbed (auger cuttings) samples and bulk samples retrieved during the sub-surface investigation were transported to TREK's material testing laboratory for further testing. Pavement core samples were also retrieved and logged at TREK's material testing laboratory

Core and test hole logs noted on the summary tables and test hole locations are based on UTM coordinates obtained using a hand-held GPS, and their location relative to the nearest address or intersection, measured distance from the edge of pavement, or other permanent features.

The laboratory testing program consisted of moisture content determination on all samples, as well as Atterberg Limits, and grain size analysis (mechanical sieve and hydrometer methods) on select samples between 0.6 and 0.9 m below pavement as well as Standard Proctor and CBR testing. Information gathered for each street package is included in separate appendices (Appendices A to F?). The information provided in the Appendices includes test hole logs, laboratory testing summary tables and results, photos of the concrete cores, and summary of pavement compressive strength.

Three CBR's were completed on bulk samples of the soil units present below the pavement. Tests were performed on clay layers encountered within the prescribed sample depth for CBR testing and the results are shown in the table below.

Table 1: CBR Testing Summary

Soil Unit	Street	Depth (m)	SPMDD (kg/m^3)	Opt. Moisture (%)	Percent Proctor (%)	Moisture Content (%)	CBR Value at 2.54 mm	CBR Value at 5.08 mm
Clay	Panet Road (TH22-01 & 02 combined)	0.5 – 1.7	1489	26.2	94.6	25.6	1.9%	1.6%
Clay	Panet Road (TH22-07 & 08 combined)	0.3-2.4	1598	23.2	95.8	22.1	1.3%	1.3%
Clay	Springfield Road (TH22-18 & 19 combined)	0.8-3.0	1465	26.5	95.0	28.0	1.6%	1.4%

The test hole logs include a description of the soil units encountered during drilling and other pertinent information such as groundwater conditions and a summary of the laboratory testing results. The soils were classified in general accordance with the Unified Soil Classification System (USCS) and the AASHTO soil classification system (American Association of state highway and transportation officials). The AASHTO system classifies soils based on laboratory testing results from Atterberg Limits and grain size testing methods (hydrometer and mechanical sieve method). Where laboratory testing was not conducted, the AASHTO classification of the soils were interpreted based on a visual assessment as indicated with a (I) on the test hole logs and attached tables. For cohesive soils, the AASHTO system uses a combination of testing results to determine the Group Index of the soils and thus, were only determined where sufficient laboratory test data was available.

Six concrete cores were selected for concrete compressive strength breaks and the length to diameter ratio ranged between 1.28 to 1.43 for the cores collected. The core compressive strength tests were tested in accordance with CSA A23.2-14C – wet dried condition. The measured compressive strengths were also corrected based on an adapted ACI 214.4R-03 Standard to estimate the in-place concrete strengths. The table below summarizes the compressive strength results while the compressive strength testing details and the correction factor methodology are included in Appendix A and D through F.

Table 2: Concrete Core Compressive Strength Results

Core ID (Location)	Uncorrected Compressive Strength (MPa)	Corrected Compressive Strength (MPa)
PC-04 (Panet Rd)	48.88	60.69
PC-05 (Panet Rd)	45.93	54.77
PC-10 (Dugald Road)	53.3	62.49
PC-14 (Mazenod Road)	46.73	55.22
PC-15 (Beghin Avenue)	59.36	63.29
PC-16 (Beghin Avenue)	51.80	55.91

3.0 Closure

The information provided in this report is in accordance with current engineering principles and practices (Standard of Practice). The findings of this report were based on information provided (field investigation, laboratory testing, geometries). Soil conditions are natural deposits that can be highly variable across a site. If sub-surface conditions are different than the conditions previously encountered on-site or those presented here, we should be notified to adjust our findings if necessary.

All information provided in this report is subject to our standard terms and conditions for engineering services, a copy of which is provided to each of our clients with the original scope of work, or a mutually executed standard engineering services agreement. If these conditions are not attached, and you are not already in possession of such terms and conditions, contact our office and you will be promptly provided with a copy.

This report has been prepared by TREK Geotechnical Inc. (the Consultant) for the exclusive use of WSP Canada Group Ltd. (the Client) and their agents for the work product presented in the report. Any findings or recommendations provided in this report are not to be used or relied upon by any third parties, except as agreed to in writing by the Client and Consultant prior to use.

Figures

Z:\Projects\1000 Soils Lab\Lab Projects\1000 Lab Projects\1000-043 WSP\1000-043-22 2023 Local Streets Package (23-RI-02)\3 Survey and Dwg\3.4 CAD\3.4.3 Working Folder\Fig 01 to 06 2022-12-09 LSP23-RI-02 0_B 1000-043-22.dwg, 2022-12-09 2:19:44 PM

TREK GEOTECHNICAL

1000 043 22

WSP Canada Group Ltd.

2023 Local and Industrial Streets Renewal Package 23-RI-02

LEGEND:

- ⊕ TEST HOLE (TREK, 2022)
- ◈ PAVEMENT CORE (TREK, 2022)

NOTES:

1. AERIAL IMAGERY FROM CITY OF WINNIPEG (2021).

0 50 100 150 m

SCALE = 1 : 2 500 (216 mm x 279 mm)

Figure 01

Test Hole and

Pavement Core Location Plan

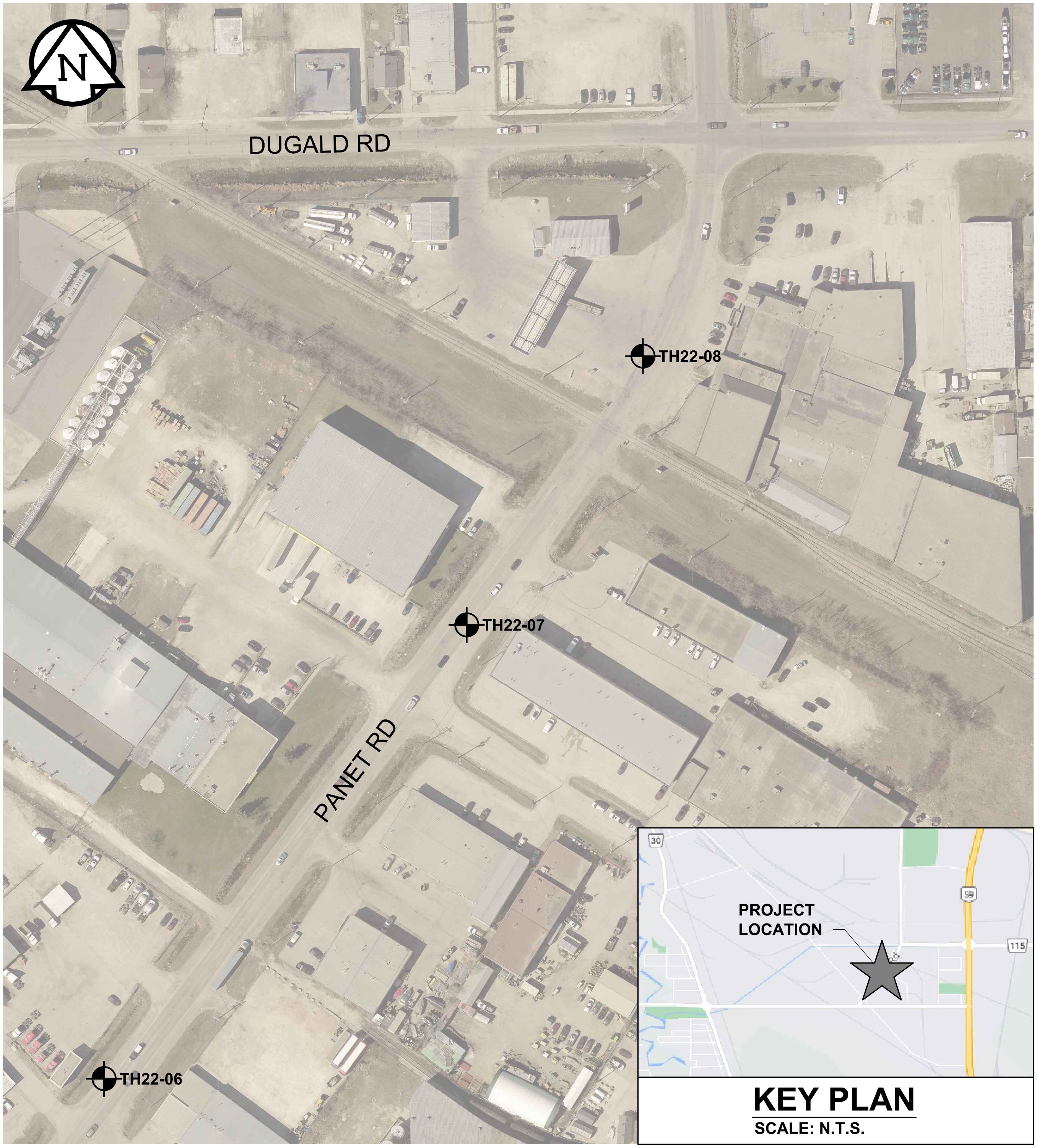
Z:\Projects\1000 Soils Lab\Lab Projects\1000 Lab Projects\1000-043 WSP\1000-043-22 2023 Local Streets Package (23-RI-02)\3 Survey and Dwg\3.4 CAD\3.4.3 Working Folder\Fig 01 to 06 2022-12-09 LSP23-RI-02 0_B 1000-043-22.dwg, 2022-12-09 2:21:15 PM

TREK GEOTECHNICAL

1000 043 22

WSP Canada Group Ltd.

2023 Local and Industrial Streets Renewal Package 23-RI-02



KEY PLAN

SCALE: N.T.S.

LEGEND:

⌖ **TEST HOLE (TREK, 2022)**

NOTES:

1. **AERIAL IMAGERY FROM CITY OF WINNIPEG (2021).**

0 25 50 75 100 m

SCALE = 1 : 2 000 (216 mm x 279 mm)

Figure 02

Test Hole Location Plan

Z:\Projects\1000 Soils Lab\Lab Projects\1000 Lab Projects\1000-043 WSP\1000-043-22 2023 Local Streets Package (23-RI-02)\3 Survey and Dwg\3.4 CAD\3.4.3 Working Folder\Fig 01 to 06 2022-12-09 LSP23-RI-02 0_C 1000-043-22.dwg, 2022-12-09 3:29:35 PM

1000 043 22

WSP Canada Group Ltd.

2023 Local and Industrial Streets Renewal Package 23-RI-02

KEY PLAN

SCALE: N.T.S.

LEGEND:

⊕ **TEST HOLE (TREK, 2022)**

NOTES:

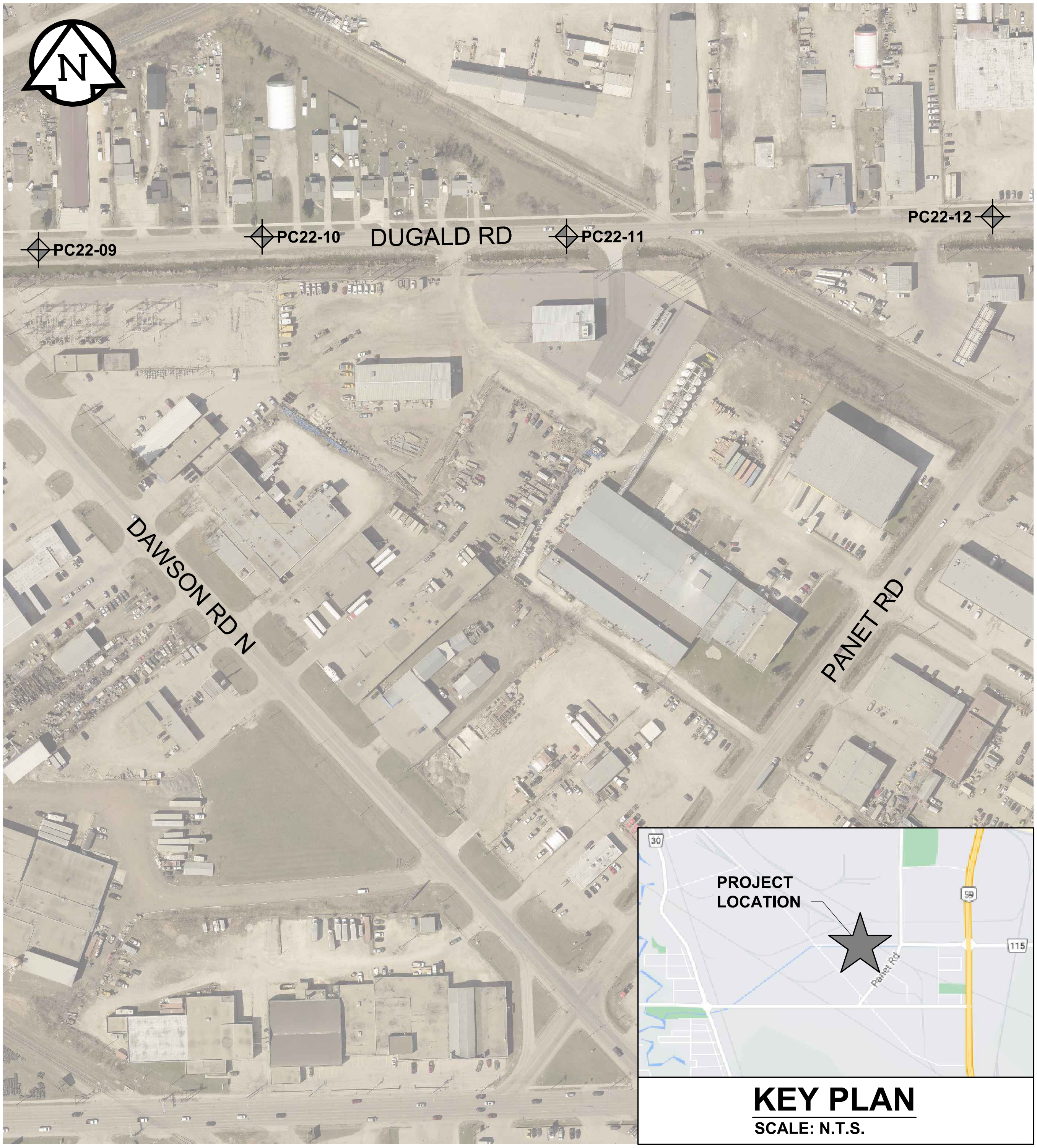
1. **AERIAL IMAGERY FROM CITY OF WINNIPEG (2021).**

0 100 200 300 m

SCALE = 1 : 7 500 (216 mm x 279 mm)

Figure 03

Test Hole Location Plan



LEGEND:

⌖ PAVEMENT CORE (TREK, 2022)

NOTES:

1. AERIAL IMAGERY FROM CITY OF WINNIPEG (2021).

0 50 100 150 m

SCALE = 1 : 3 000 (216 mm x 279 mm)

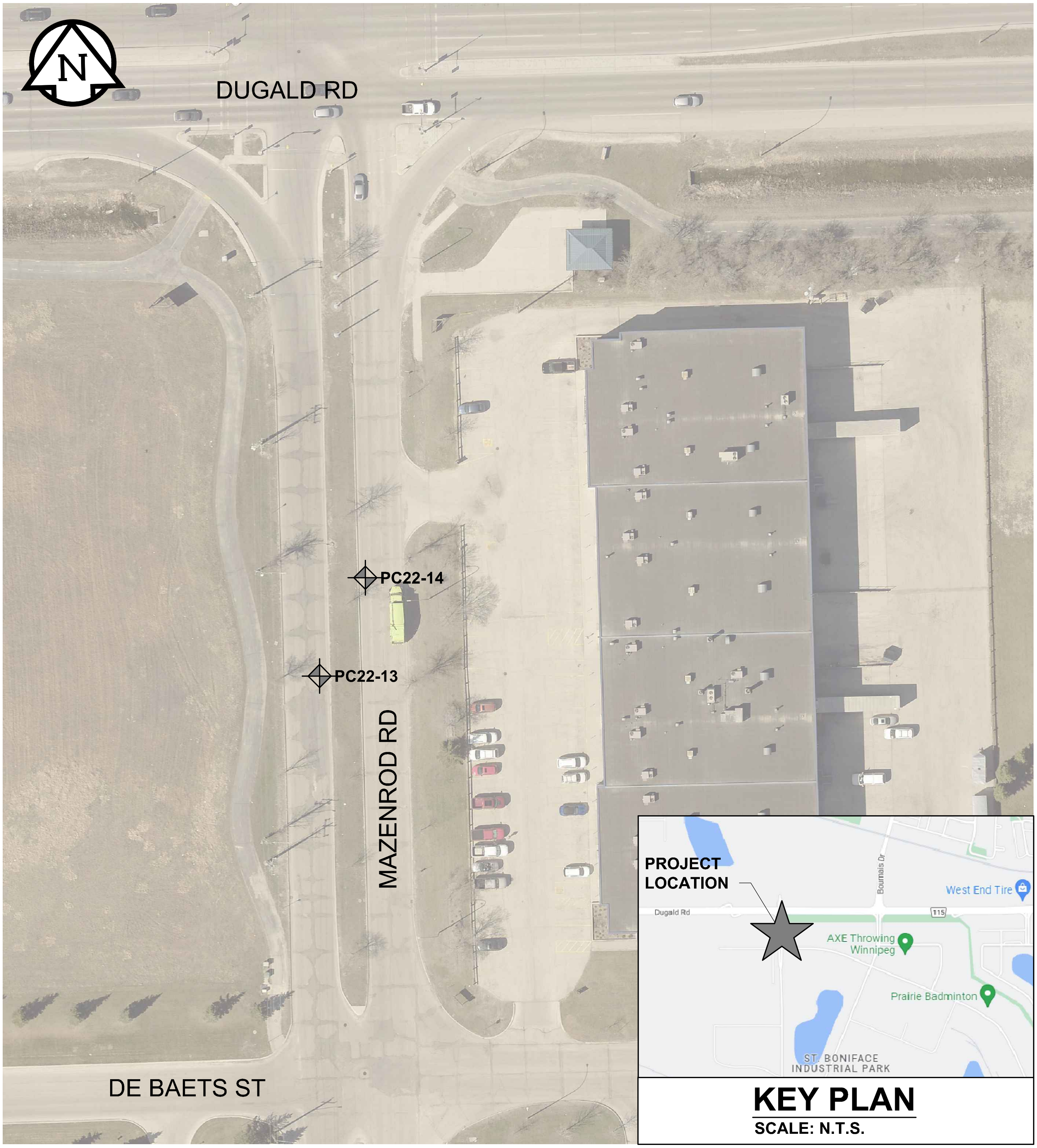
Figure 04

Pavement Core Location Plan

1000 043 22

WSP Canada Group Ltd.

2023 Local and Industrial Streets Renewal Package 23-RI-02



LEGEND:

- ⌖ **PAVEMENT CORE (TREK, 2022)**

NOTES:

1. **AERIAL IMAGERY FROM CITY OF WINNIPEG (2021).**

0 10 20 30 40 50 m

SCALE = 1 : 1 000 (216 mm x 279 mm)

Figure 05

Pavement Core Location Plan

Z:\Projects\1000 Soils Lab\Lab Projects\1000 Lab Projects\1000-043 WSP\1000-043-22 2023 Local Streets Package (23-RI-02)\3 Survey and Dwg\3.4 CAD\3.4.3 Working Folder\Fig 01 to 06 2022-12-09 LSP23-RI-02 0_C 1000-043-22.dwg, 2022-12-09 3:28:53 PM

1000 043 22

WSP Canada Group Ltd.

2023 Local and Industrial Streets Renewal Package 23-RI-02

KEY PLAN

SCALE: N.T.S.

LEGEND:

⌖ PAVEMENT CORE (TREK, 2022)

NOTES:

1. AERIAL IMAGERY FROM CITY OF WINNIPEG (2021).

SCALE = 1 : 2 000 (216 mm x 279 mm)

Figure 06

Pavement Core Location Plan

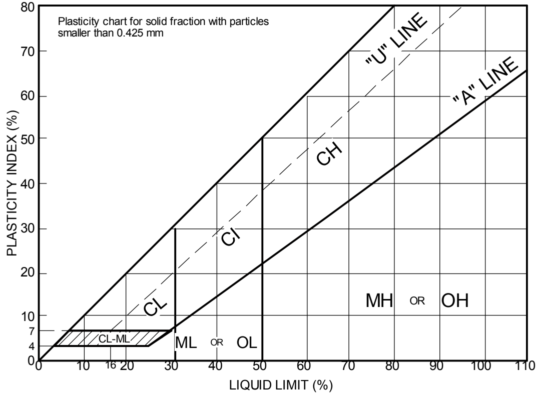
Appendix A

Test Hole Logs, Summary Table & Lab Testing Results and Pavement Core Photos – Panet Rd (between Nairn Ave and CPR tracks)

EXPLANATION OF FIELD AND LABORATORY TESTING

GENERAL NOTES

1. Classifications are based on the United Soil Classification System and include consistency, moisture, and color. Field descriptions have been modified to reflect results of laboratory tests where deemed appropriate.
2. Descriptions on these test hole logs apply only at the specific test hole locations and at the time the test holes were drilled. Variability of soil and groundwater conditions may exist between test hole locations.
3. When the following classification terms are used in this report or test hole logs, the primary and secondary soil fractions may be visually estimated.

Major Divisions			USCS Classification	Symbols	Typical Names	Laboratory Classification Criteria		
Coarse-Grained soils (More than half the material is larger than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than 4.75 mm)	Clean gravel (Little or no fines)	GW	●	Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain size curve, depending on percentage of fines (fraction smaller than No. 200 sieve) coarse-grained soils are classified as follows: Less than 5 percent...... GW, GP, SW, SP More than 12 percent...... GM, GC, SM, SC 6 to 12 percent...... Borderline case4s requiring dual symbols*	$C_U = \frac{D_{60}}{D_{10}}$ greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			GP	○	Poorly-graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW	
		Gravel with fines (Appreciable amount of fines)	GM	○	Silty gravels, gravel-sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are border-line cases requiring use of dual symbols
			GC	▩	Clayey gravels, gravel-sand-silt mixtures		Atterberg limits above "A" line or P.I. greater than 7	
	Sands (More than half of coarse fraction is smaller than 4.75 mm)	Clean sands (Little or no fines)	SW	░	Well-graded sands, gravelly sands, little or no fines		$C_U = \frac{D_{60}}{D_{10}}$ greater than 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			SP	░	Poorly-graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM	░	Silty sands, sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are border-line cases requiring use of dual symbols
			SC	░	Clayey sands, sand-clay mixtures		Atterberg limits above "A" line or P.I. greater than 7	
Fine-Grained soils (More than half the material is smaller than No. 200 sieve size)	Silts and Clays (Liquid limit less than 50)		ML	▥	Inorganic silts and very fine sands, rock floor, silty or clayey fine sands or clayey silts with slight plasticity	Plasticity Chart 		
			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 distomaceous fine sandy or silty soils, organic silts			
			CH	▨	Inorganic clays of high plasticity, fat clays			
			OH	≋	Organic clays of medium to high plasticity, organic silts			
	Highly Organic Soils		Pt	⁂	Peat and other highly organic soils	Von Post Classification Limit	Strong colour or odour, and often fibrous texture	

Material		Particle Size mm	Particle Size ASTM Sieve sizes
Sand	Coarse	2.00 to 4.75	#10 to #4
	Medium	0.425 to 2.00	#40 to #10
	Fine	0.075 to 0.425	#200 to #40
Silt or Clay		< 0.075	< #200

Material		Particle Size mm	Particle Size ASTM Sieve Sizes
Boulders		> 300	> 12 in.
Cobbles		75 to 300	3 in. to 12 in.
Gravel	Coarse	19 to 75	3/4 in. to 3 in.
	Fine	4.75 to 19	#4 to 3/4 in.

* Borderline classifications used for soils possessing characteristics of two groups are designated by combinations of groups symbols. For example; GW-GC, well-graded gravel-sand mixture with clay binder.

Other Symbol Types

■	Asphalt	▧	Bedrock (undifferentiated)	○	Cobbles
░	Concrete	⊞	Limestone Bedrock	●	Boulders and Cobbles
▩	Fill	▤	Cemented Shale	▥	Silt Till
		▧	Non-Cemented Shale	▩	Clay Till

EXPLANATION OF FIELD AND LABORATORY TESTING

LEGEND OF ABBREVIATIONS AND SYMBOLS

LL - Liquid Limit (%)
PL - Plastic Limit (%)
PI - Plasticity Index (%)
MC - Moisture Content (%)
SPT - Standard Penetration Test
RQD - Rock Quality Designation
Qu - Unconfined Compression
Su - Undrained Shear Strength
VW - Vibrating Wire Piezometer
SI - Slope Inclinometer

▽ Water Level at Time of Drilling

▼ Water Level at End of Drilling

⧨ Water Level After Drilling as Indicated on Test Hole Logs

FRACTION OF SECONDARY SOIL CONSTITUENTS ARE BASED ON THE FOLLOWING TERMINOLOGY

TERM	EXAMPLES	PERCENTAGE
and	and CLAY	35 to 50 percent
"y" or "ey"	clayey, silty	20 to 35 percent
some	some silt	10 to 20 percent
trace	trace gravel	1 to 10 percent

TERMS DESCRIBING CONSISTENCY OR COMPACTION CONDITION

The Standard Penetration Test blow count (N) of a non-cohesive soil can be related to compactness condition as follows:

Descriptive Terms	SPT (N) (Blows/300 mm)
Very loose	< 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	> 50

The Standard Penetration Test blow count (N) of a cohesive soil can be related to its consistency as follows:

Descriptive Terms	SPT (N) (Blows/300 mm)
Very soft	< 2
Soft	2 to 4
Firm	4 to 8
Stiff	8 to 15
Very stiff	15 to 30
Hard	> 30

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

Descriptive Terms	Undrained Shear Strength (kPa)
Very soft	< 12
Soft	12 to 25
Firm	25 to 50
Stiff	50 to 100
Very stiff	100 to 200
Hard	> 200

Sub-Surface Log

Test Hole TH22-01 (Panet Rd)

1 of 1

Client: WSP Canada Group Ltd.

Project Number: 1000-043-22

Project Name: 2023 Local and Industrial Streets Renewal Package (23-RI-02)

Location: UTM N-5528813, E-638120

Contractor: Maple Leaf Drilling Ltd.

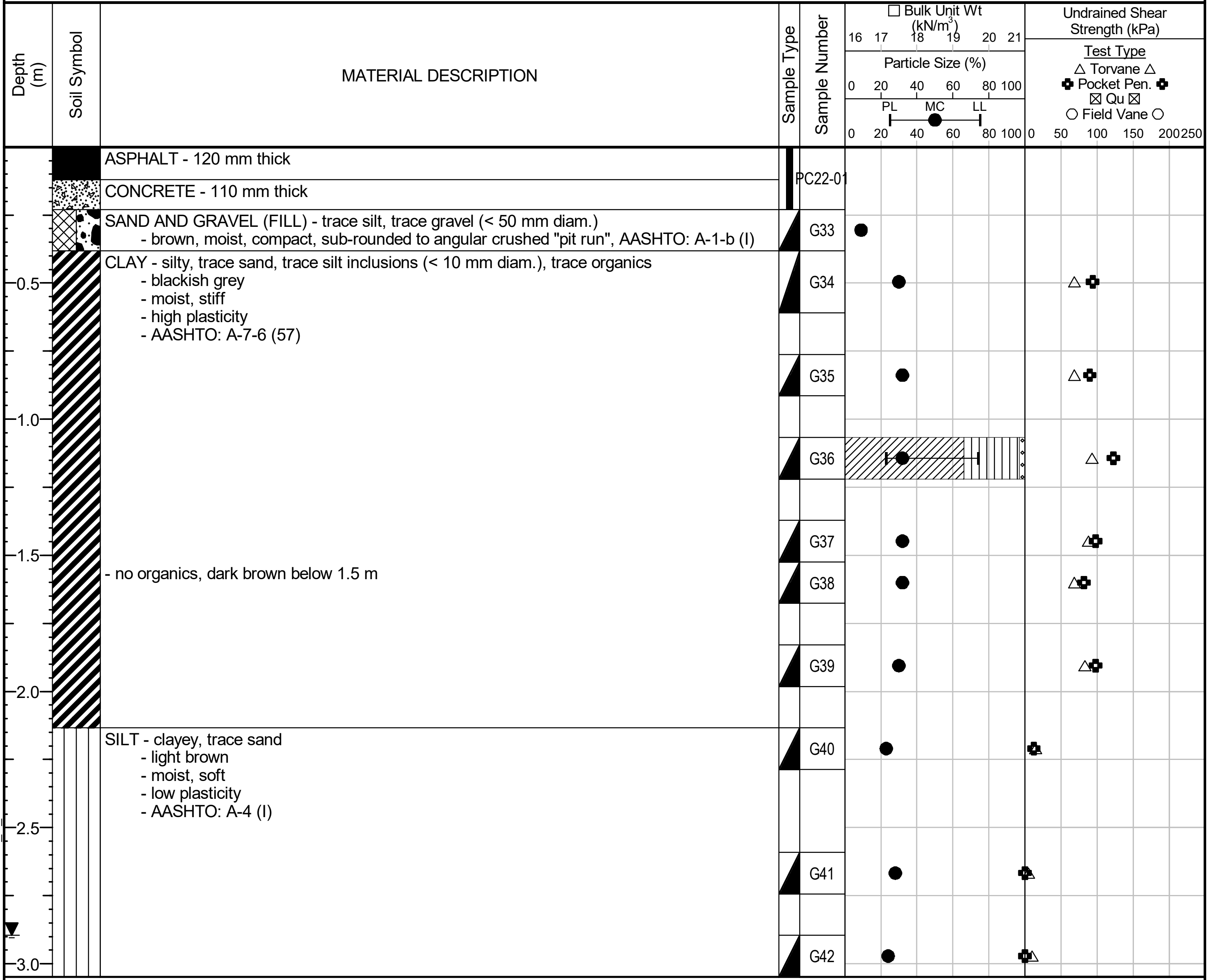
Ground Elevation: Top of Pavement

Method: 125mm Solid Stem Auger, B40 Mobile Truck Mount

Date Drilled: November 15, 2022

Sample Type: ◩ Grab (G) ◨ Shelby Tube (T) ☒ Split Spoon (SS) / SPT ☒ Split Barrel (SB) / LPT ◨ Core (C)

Particle Size Legend: ▦ Fines ▨ Clay ▥ Silt ░ Sand ● Gravel ◌ Cobbles ■ Boulders



ASPHALT - 120 mm thick

CONCRETE - 110 mm thick

SAND AND GRAVEL (FILL) - trace silt, trace gravel (< 50 mm diam.)
- brown, moist, compact, sub-rounded to angular crushed "pit run", AASHTO: A-1-b (I)

CLAY - silty, trace sand, trace silt inclusions (< 10 mm diam.), trace organics
- blackish grey
- moist, stiff
- high plasticity
- AASHTO: A-7-6 (57)

- no organics, dark brown below 1.5 m

SILT - clayey, trace sand
- light brown
- moist, soft
- low plasticity
- AASHTO: A-4 (I)

END OF TEST HOLE AT 3.0 m IN SILT.
1) Sloughing not observed.
2) Seepage observed below 2.1 m depth.
3) Test hole open to 3.0 m depth and ground water level at 2.9 m depth immediately after drilling.
4) Test hole backfilled with auger cuttings, bentonite chips and cold patch asphalt.
5) Test hole located in front of #475 Panet Rd, 1.5 m West of East edge of road.
6) The bulk sample was collected between 0.5 and 2.1 m depth.

Logged By: Jashandeep Singh Bhullar

Reviewed By: Angela Fidler-Kliewer

Project Engineer: Nelson Ferreira

TREK GEOTECHNICAL

Sub-Surface Log

Test Hole TH22-02 (Panet Rd)

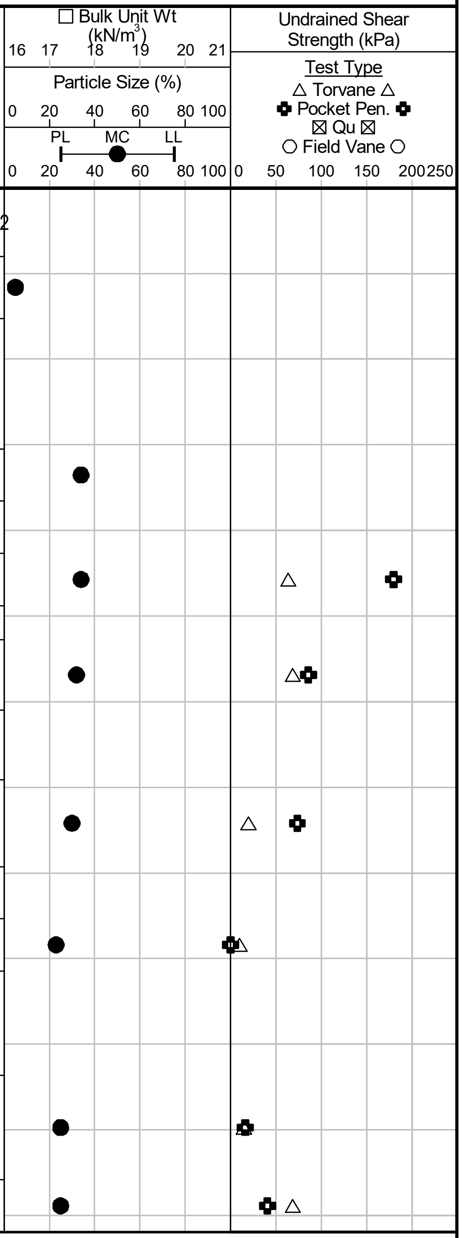
1 of 1

Client: WSP Canada Group Ltd.
Project Number: 1000-043-22
Project Name: 2023 Local and Industrial Streets Renewal Package (23-RI-02)
Location: UTM N-5528925, E-638219
Contractor: Maple Leaf Drilling Ltd.
Ground Elevation: Top of Pavement
Method: 125mm Solid Stem Auger, B40 Mobile Truck Mount
Date Drilled: November 15, 2022

Sample Type: ◩ Grab (G) ◨ Shelby Tube (T) ☒ Split Spoon (SS) / SPT ☒ Split Barrel (SB) / LPT ◨ Core (C)

Particle Size Legend: ▦ Fines ▨ Clay ▥ Silt ░ Sand ▚ Gravel ▱ Cobbles ■ Boulders

Depth (m)	MATERIAL DESCRIPTION	Sample Number
	ASPHALT - 85 mm thick	PC22-02
	CONCRETE - 115 mm thick	
	SAND AND GRAVEL (FILL) - trace silt, trace gravel (< 50 mm diam.) - brown, moist, compact, sub-rounded to angular crushed "pit run", AASHTO: A-1-b (I)	G16
0.5	CLAY - silty, trace gravel (< 75 mm diam.) - greyish black - moist, very stiff - high plasticity - AASHTO: A-7-6 (I)	
		G17
1.0		
	- no gravel, browninsh grey below 1.1 m	G18
	- stiff below 1.4 m	G19
1.5		
	SILT - clayey - brown - moist, soft - low plasticity - AASHTO: A-4 (I)	G20
2.0		
		G21
2.5 ▼		
		G22
	CLAY - silty - brown, moist, stiff, high plasticity, AASHTO: A-7-6 (I)	G23
3.0		



END OF TEST HOLE AT 3.0 m IN CLAY.
1) Seepage observed below 1.7 m depth.
2) Sloughing not observed.
3) Test hole open to 3.0 m depth and ground water level at 2.6 m depth immediately after drilling.
4) Test hole backfilled with auger cuttings, bentonite chips and cold patch asphalt.
5) Test hole located in front of #481 Panet Rd, 2.1 m East of West edge of road.
6) The bulk sample was collected between 0.5 and 1.7 m depth.

Logged By: Jashandeep Singh Bhullar **Reviewed By:** Angela Fidler-Kliewer **Project Engineer:** Nelson Ferreira

TREK GEOTECHNICAL

Sub-Surface Log

Test Hole TH22-03 (Panet Rd)

Client: WSP Canada Group Ltd.

Project Number: 1000-043-22

Project Name: 2023 Local and Industrial Streets Renewal Package (23-RI-02)

Location: UTM N-5529041, E-638338

Contractor: Maple Leaf Drilling Ltd.

Ground Elevation: Top of Pavement

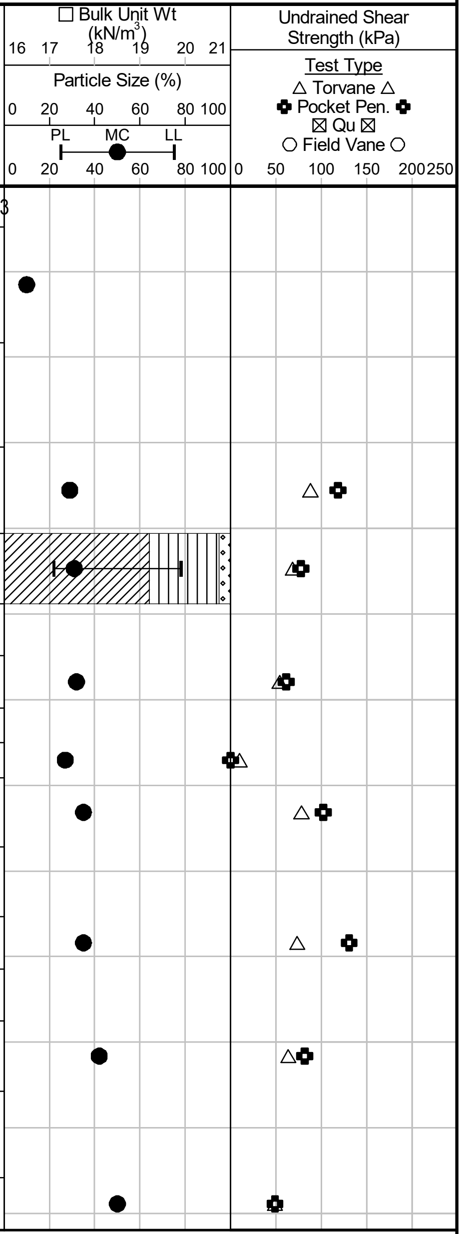
Method: 125mm Solid Stem Auger, B40 Mobile Truck Mount

Date Drilled: November 15, 2022

Sample Type: ◢ Grab (G) ▮ Shelby Tube (T) ☒ Split Spoon (SS) / SPT ⧓ Split Barrel (SB) / LPT ▮ Core (C)

Particle Size Legend: ▦ Fines ▨ Clay ▥ Silt ⁘ Sand ● Gravel ◌ Cobbles ■ Boulders

Depth (m)	Soil Symbol	MATERIAL DESCRIPTION	Sample Type	Sample Number
		ASPHALT - 120 mm thick	▮	PC22-03
		SAND AND GRAVEL (FILL) - trace clay, trace silt, trace gravel (< 50 mm diam.) - brown, moist - compact to dense, no to low plasticity - sub-rounded to angular crushed "pitrun", AASHTO: A-1-b (I)	◢	G24
0.5				
		CLAY - silty, trace sand - black - moist, very stiff - high plasticity - AASHTO: A-7-6 (60)	◢	G25
1.0		- browninsh grey, stiff below 1.0 m	◢	G26
			◢	G27
1.5				
		SILT - clayey, brown, moist, soft, low plasticity, AASHTO: A-4 (I)	◢	G28
		CLAY - silty, trace silt inclusions (< 20 mm diam.) - brown - moist, stiff - high plasticity - AASHTO: A-7-6 (I)	◢	G29
2.0				
			◢	G30
2.5		- light brown below 2.4 m	◢	G31
3.0			◢	G32



END OF TEST HOLE AT 3.0 m IN CLAY.
1) Seepage or sloughing not observed.
2) Test hole open dry and open to 3.0 m depth immediately after drilling.
3) Test hole backfilled with auger cuttings, bentonite chips and cold patch asphalt.
4) Test hole located in front of #435 Unit 2 Panet Rd, 0.4 m West of East edge of road.
5) The bulk sample was collected between 0.5 to 1.6 m and 1.6 to 3.0 m depth.

Logged By: Jashandeep Singh Bhullar

Reviewed By: Angela Fidler-Kliewer

Project Engineer: Nelson Ferreira

2023 Local and Industrial Streets Renewal Project - 23-RI-02
Sub-Surface Investigation
Panet Rd - Narin Av / CPR Tracks

Test Hole No.	Test Hole Location	Pavement Surface		Pavement Structure Material		Subgrade Description	Sample Depth (m)		Moisture Content (%)	Grain Size Analysis				Atterberg Limits		
		Type	Thickness (mm)	Type	Thickness (mm)		Top (m)	Bottom (m)		Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Plastic	Liquid	Plasticity Index
TH22-01	UTM: 14U 5528813 N, 638120 E Located in front of #475 Panet Rd, 1.5 m West of East edge of road.	Asphalt	120	Concrete	110	Sand and Gravel (Fill); AASHTO: A-7-6 (I)	0.2	0.4	9							
						Clay; AASHTO: A-7-6 (57)	0.4	0.6	30							
						Clay; AASHTO: A-7-6 (57)	0.8	0.9	32							
						Clay; AASHTO: A-7-6 (57)	1.1	1.2	32	66	31	3	0	23	74	52
						Clay; AASHTO: A-7-6 (57)	1.4	1.5	32							
						Clay; AASHTO: A-7-6 (57)	1.5	1.7	32							
						Clay; AASHTO: A-7-6 (57)	1.8	2.0	30							
						Silt; AASHTO: A-4 (I)	2.1	2.3	23							
						Silt; AASHTO: A-4 (I)	2.6	2.7	28							
						Silt; AASHTO: A-4 (I)	2.9	3.0	24							
TH22-02	UTM: 14U 5528925 N, 638219 E Located in front of #481 Panet Rd, 2.1 m East of West edge of road.	Asphalt	85	Concrete	115	Sand and Gravel (Fill); AASHTO: A-1-b (I)	0.2	0.4	5							
						Clay; AASHTO: A-7-6 (I)	0.8	0.9	34							
						Clay; AASHTO: A-7-6 (I)	1.1	1.2	34							
						Clay; AASHTO: A-7-6 (I)	1.3	1.5	32							
						Silt; AASHTO: A-4 (I)	1.7	2.0	30							
						Silt; AASHTO: A-4 (I)	2.1	2.3	23							
						Silt; AASHTO: A-4 (I)	2.6	2.9	25							
						Clay; AASHTO: A-7-6 (I)	2.9	3.0	25							
TH22-03	UTM: 14U 5529041 N, 638338 E Located in front of #435 Unit 2 Panet Rd, 0.4 m West of East edge of road.	Asphalt	120	Concrete	-	Sand and Gravel (Fill); AASHTO: A-1-b (I)	0.1	0.5	10							
						Clay; AASHTO: A-7-6 (60)	0.8	1.0	29							
						Clay; AASHTO: A-7-6 (60)	1.0	1.2	31	64	31	5	0	22	78	56
						Clay; AASHTO: A-7-6 (60)	1.4	1.5	32							
						Silt; AASHTO: A-4 (I)	1.6	1.7	27							
						Clay; AASHTO: A-7-6 (I)	1.7	1.9	35							
						Clay; AASHTO: A-7-6 (I)	2.1	2.3	35							
						Clay; AASHTO: A-7-6 (I)	2.4	2.6	42							
						Clay; AASHTO: A-7-6 (I)	2.9	3.0	50							

(I) - AASHTO classification was interpreted based on visual classification.

TREK GEOTECHNICAL
www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

Moisture Content Report
ASTM D2216-10

Project No. 1000-043-22
Client WSP Canada Group LTD
Project 2023 Local and Industrial Streets Package (23-RI-02) - Panet Rd.

Sample Date 25-Nov-22
Test Date 29-Nov-22
Technician TR

Test Hole	TH22-01	TH22-01	TH22-01	TH22-01	TH22-01	TH22-01
Depth (m)	0.2 - 0.4	0.4 - 0.6	0.8 - 0.9	1.1 - 1.2	1.4 - 1.5	1.5 - 1.7
Sample #	G33	G34	G35	G36	G37	G38
Tare ID	N64	H22	W13	AB96	E33	P36
Mass of tare	8.8	9.1	8.5	6.9	8.5	8.7
Mass wet + tare	372.2	234.6	323.5	416.8	254.7	289.6
Mass dry + tare	341.3	182.3	246.6	317.4	195.1	221.2
Mass water	30.9	52.3	76.9	99.4	59.6	68.4
Mass dry soil	332.5	173.2	238.1	310.5	186.6	212.5
Moisture %	9.3%	30.2%	32.3%	32.0%	31.9%	32.2%

Test Hole	TH22-01	TH22-01	TH22-01	TH22-01	TH22-02	TH22-02
Depth (m)	1.8 - 2.0	2.1 - 2.3	2.6 - 2.7	2.9 - 3.0	0.2 - 0.5	0.8 - 0.9
Sample #	G39	G40	G41	G42	G16	G17
Tare ID	F104	Z07	W10	AB69	AC26	H2
Mass of tare	8.5	8.8	8.5	6.8	6.8	8.6
Mass wet + tare	296.8	319.5	319.2	388.5	488.6	284.7
Mass dry + tare	230.2	261.7	250.9	313.8	466.7	214.8
Mass water	66.6	57.8	68.3	74.7	21.9	69.9
Mass dry soil	221.7	252.9	242.4	307.0	459.9	206.2
Moisture %	30.0%	22.9%	28.2%	24.3%	4.8%	33.9%

Test Hole	TH22-02	TH22-02	TH22-02	TH22-02	TH22-02	TH22-02
Depth (m)	1.1 - 1.2	1.3 - 1.5	1.7 - 2.0	2.1 - 2.3	2.6 - 2.9	2.9 - 3.0
Sample #	G18	G19	G20	G21	G22	G23
Tare ID	P40	D37	Z59	N28	K19	W46
Mass of tare	8.8	8.6	8.0	8.4	8.5	8.7
Mass wet + tare	304.1	289.2	265.2	323.2	300.2	284.4
Mass dry + tare	228.5	220.6	205.7	265.4	242.1	228.9
Mass water	75.6	68.6	59.5	57.8	58.1	55.5
Mass dry soil	219.7	212.0	197.7	257.0	233.6	220.2
Moisture %	34.4%	32.4%	30.1%	22.5%	24.9%	25.2%

www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

Moisture Content Report
ASTM D2216-10

Project No. 1000-043-22
Client WSP Canada Group LTD
Project 2023 Local and Industrial Streets Package (23-RI-02) - Panet Rd.

Sample Date 25-Nov-22
Test Date 29-Nov-22
Technician TR

Test Hole	TH22-03	TH22-03	TH22-03	TH22-03	TH22-03	TH22-03
Depth (m)	0.1 - 0.5	0.8 - 1.0	1.0 - 1.2	1.4 - 1.5	1.6 - 1.7	1.7 - 1.9
Sample #	G24	G25	G26	G27	G28	G29
Tare ID	D38	AB64	K37	D32	A101	H21
Mass of tare	8.4	6.7	8.5	8.6	8.7	9.2
Mass wet + tare	418.1	343.4	400.0	268.5	361.6	312.5
Mass dry + tare	380.2	268.1	306.6	205.3	286.6	234.6
Mass water	37.9	75.3	93.4	63.2	75.0	77.9
Mass dry soil	371.8	261.4	298.1	196.7	277.9	225.4
Moisture %	10.2%	28.8%	31.3%	32.1%	27.0%	34.6%

Test Hole	TH22-03	TH22-03	TH22-03			
Depth (m)	2.1 - 2.3	2.4 - 2.7	2.9 - 3.0			
Sample #	G30	G31	G32			
Tare ID	N02	P51	N99			
Mass of tare	8.6	8.6	8.5			
Mass wet + tare	287.4	275.6	224.1			
Mass dry + tare	215.7	197.0	152.4			
Mass water	71.7	78.6	71.7			
Mass dry soil	207.1	188.4	143.9			
Moisture %	34.6%	41.7%	49.8%			

TREK GEOTECHNICAL
www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

Atterberg Limits
ASTM D4318-10e1

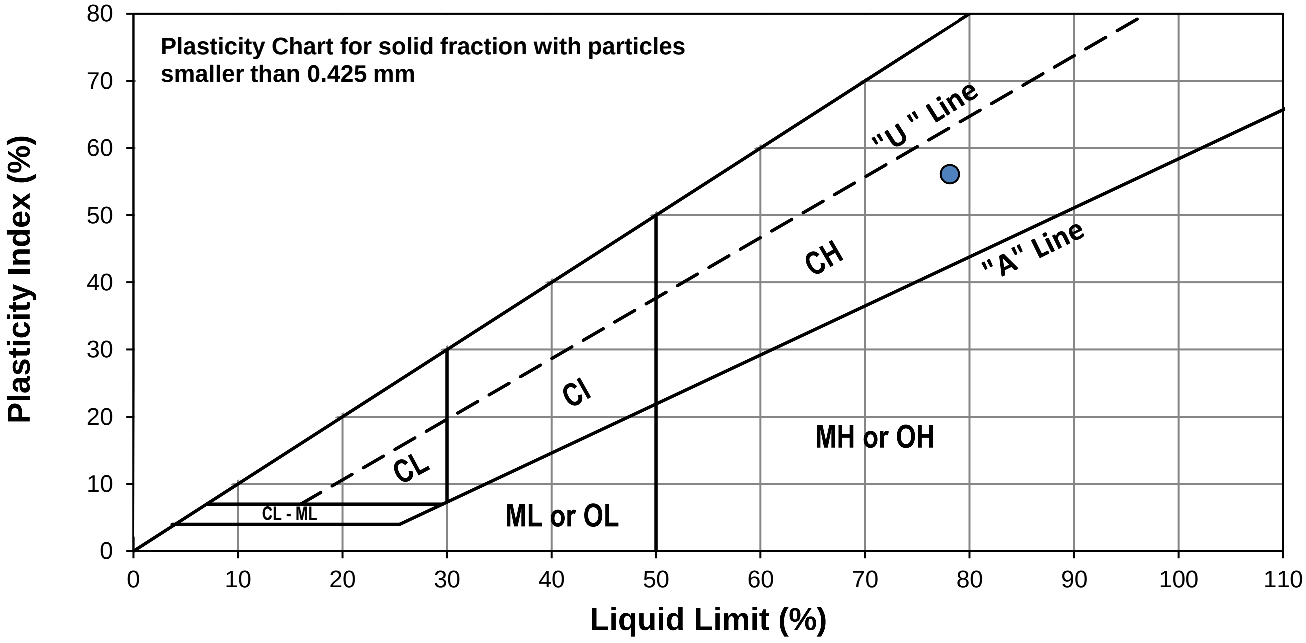
Project No. 1000-043-21
Client WSP Canada Group Ltd.
Project 2023 Local and Industrial Streets Package (23-R1-01)-Panet Rd

Test Hole TH22-03
Sample # G26
Depth (m) 1.0 - 1.3
Sample Date 15-Nov-22
Test Date 29-Nov-22
Technician MT

Liquid Limit	78
Plastic Limit	22
Plasticity Index	56

Liquid Limit

Trial #	1	2	3		
Number of Blows (N)	18	21	34		
Mass Tare (g)	14.165	14.083	13.838		
Mass Wet Soil + Tare (g)	24.150	23.181	28.223		
Mass Dry Soil + Tare (g)	19.717	19.173	21.979		
Mass Water (g)	4.433	4.008	6.244		
Mass Dry Soil (g)	5.552	5.090	8.141		
Moisture Content (%)	79.845	78.743	76.698		



Plastic Limit

Trial #	1	2	3	4	5
Mass Tare (g)	14.090	14.054			
Mass Wet Soil + Tare (g)	23.018	25.919			
Mass Dry Soil + Tare (g)	21.406	23.776			
Mass Water (g)	1.612	2.143			
Mass Dry Soil (g)	7.316	9.722			
Moisture Content (%)	22.034	22.043			

Note: Additional information recorded/measured for this test is available upon request.

TREK GEOTECHNICAL
www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

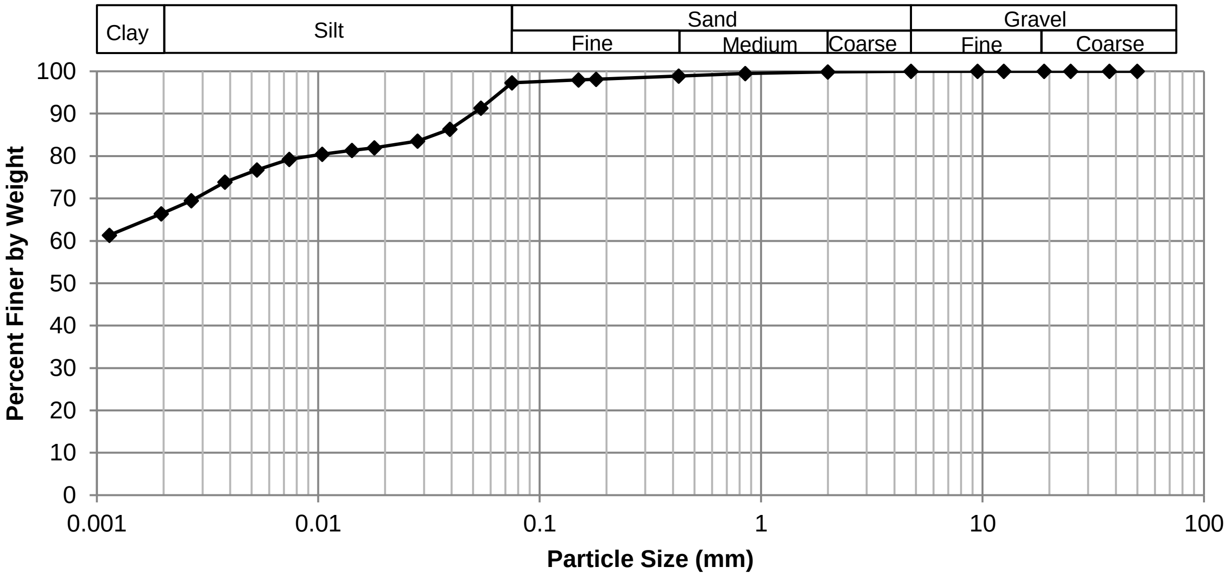
Grain Size Analysis (Hydrometer Method)
AASHTO T 88

CERTIFIED BY CCIL Canadian Council of Independent Laboratories For specific tests as listed on www.ccil.com

Project No.	1000-043-22
Client	WSP Canada Group Ltd.
Project	2023 Local Street and Industrial Package (23-RI-02) Panet Rd
Test Hole	TH22-01
Sample #	G36
Depth (m)	1.1 - 1.2
Sample Date	14-Nov-22
Test Date	29-Nov-22
Technician	DS

Gravel	0.0%
Sand	2.7%
Silt	30.7%
Clay	66.5%

Particle Size Distribution Curve



Gravel		Sand		Silt and Clay	
Particle Size (mm)	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**
50.0	100.00	4.75	100.00	0.0750	97.26
37.5	100.00	2.00	99.89	0.0543	91.34
25.0	100.00	0.850	99.51	0.0393	86.34
19.0	100.00	0.425	98.90	0.0282	83.53
12.5	100.00	0.180	98.15	0.0180	81.92
9.50	100.00	0.150	98.01	0.0142	81.34
4.75	100.00	0.075	97.26	0.0104	80.41
				0.0074	79.20
				0.0053	76.70
				0.0038	73.89
				0.0027	69.47
				0.0020	66.35
				0.0011	61.36

TREK GEOTECHNICAL
www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

Atterberg Limits
ASTM D4318-10e1

CERTIFIED BY CCIL Canadian Council of Independent Laboratories For specific tests as listed on www.ccil.com

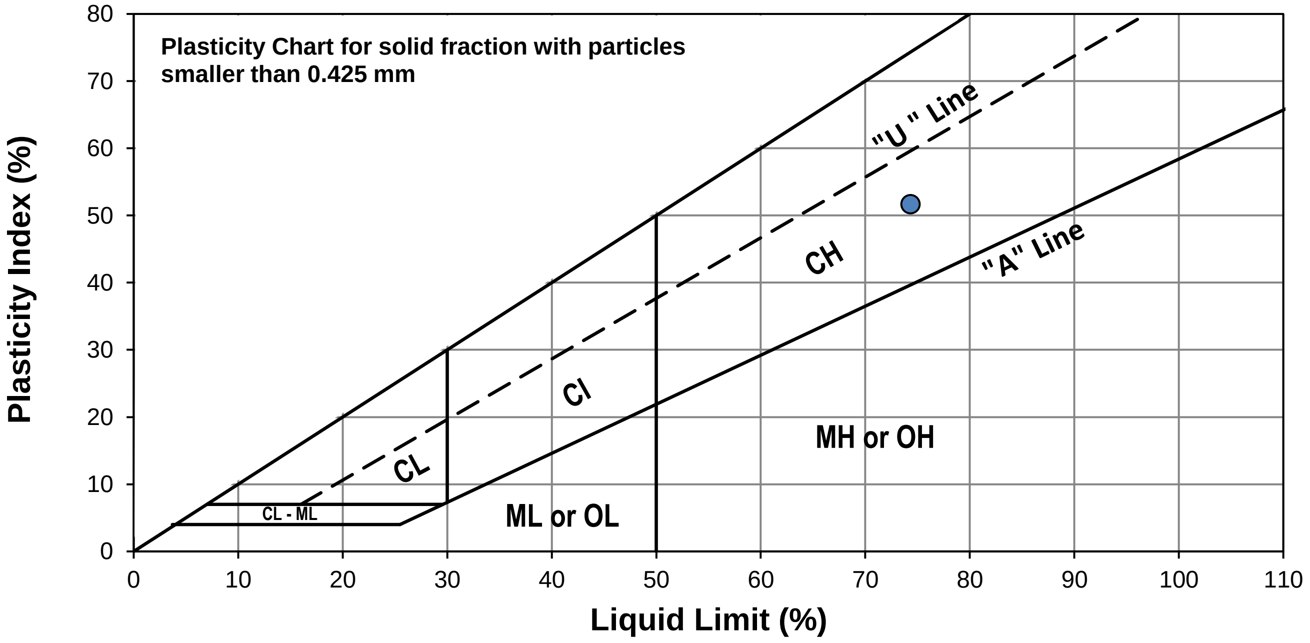
Project No. 1000-043-21
Client WSP Canada Group Ltd.
Project 2023 Local and Industrial StreetsPackage (23-R1-01) -Panet Rd

Test Hole TH22-01
Sample # G36
Depth (m) 1.1 - 1.2
Sample Date 15-Nov-22
Test Date 29-Nov-22
Technician MT

Liquid Limit	74
Plastic Limit	23
Plasticity Index	52

Liquid Limit

Trial #	**1**	**2**	**3**		
Number of Blows (N)	16	24	29		
Mass Tare (g)	14.202	14.010	13.444		
Mass Wet Soil + Tare (g)	26.668	25.514	22.432		
Mass Dry Soil + Tare (g)	21.100	20.560	18.680		
Mass Water (g)	5.568	4.954	3.752		
Mass Dry Soil (g)	6.898	6.550	5.236		
Moisture Content (%)	80.719	75.634	71.658		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Tare (g)	13.947	14.111			
Mass Wet Soil + Tare (g)	24.795	26.451			
Mass Dry Soil + Tare (g)	22.788	24.170			
Mass Water (g)	2.007	2.281			
Mass Dry Soil (g)	8.841	10.059			
Moisture Content (%)	22.701	22.676			

Note: Additional information recorded/measured for this test is available upon request.

TREK GEOTECHNICAL
www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

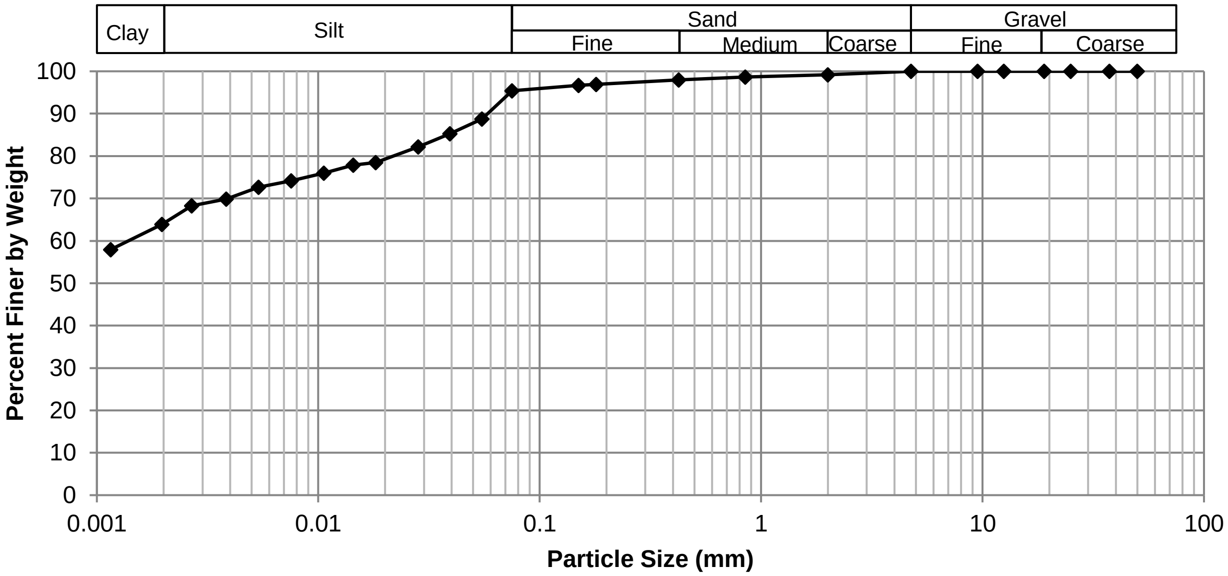
Grain Size Analysis (Hydrometer Method)
AASHTO T 88

CERTIFIED BY CCIL Canadian Council of Independent Laboratories
For specific tests as listed on www.ccil.com

Project No.	1000-043-22
Client	WSP Canada Group Ltd.
Project	2023 Local Street and Industrial Package (23-RI-02) Panet Rd
Test Hole	TH22-03
Sample #	G26
Depth (m)	1.0 - 1.2
Sample Date	14-Nov-22
Test Date	29-Nov-22
Technician	DS

Gravel	0.0%
Sand	4.6%
Silt	31.3%
Clay	64.1%

Particle Size Distribution Curve



Gravel		Sand		Silt and Clay	
Particle Size (mm)	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**
50.0	100.00	4.75	100.00	0.0750	95.38
37.5	100.00	2.00	99.21	0.0548	88.72
25.0	100.00	0.850	98.63	0.0394	85.31
19.0	100.00	0.425	97.98	0.0283	82.21
12.5	100.00	0.180	96.94	0.0182	78.45
9.50	100.00	0.150	96.67	0.0144	77.87
4.75	100.00	0.075	95.38	0.0106	76.01
				0.0076	74.18
				0.0054	72.63
				0.0038	69.83
				0.0027	68.25
				0.0020	63.91
				0.0012	57.94

www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

Standard Proctor Compaction Test

ASTM D698-12 (2021)

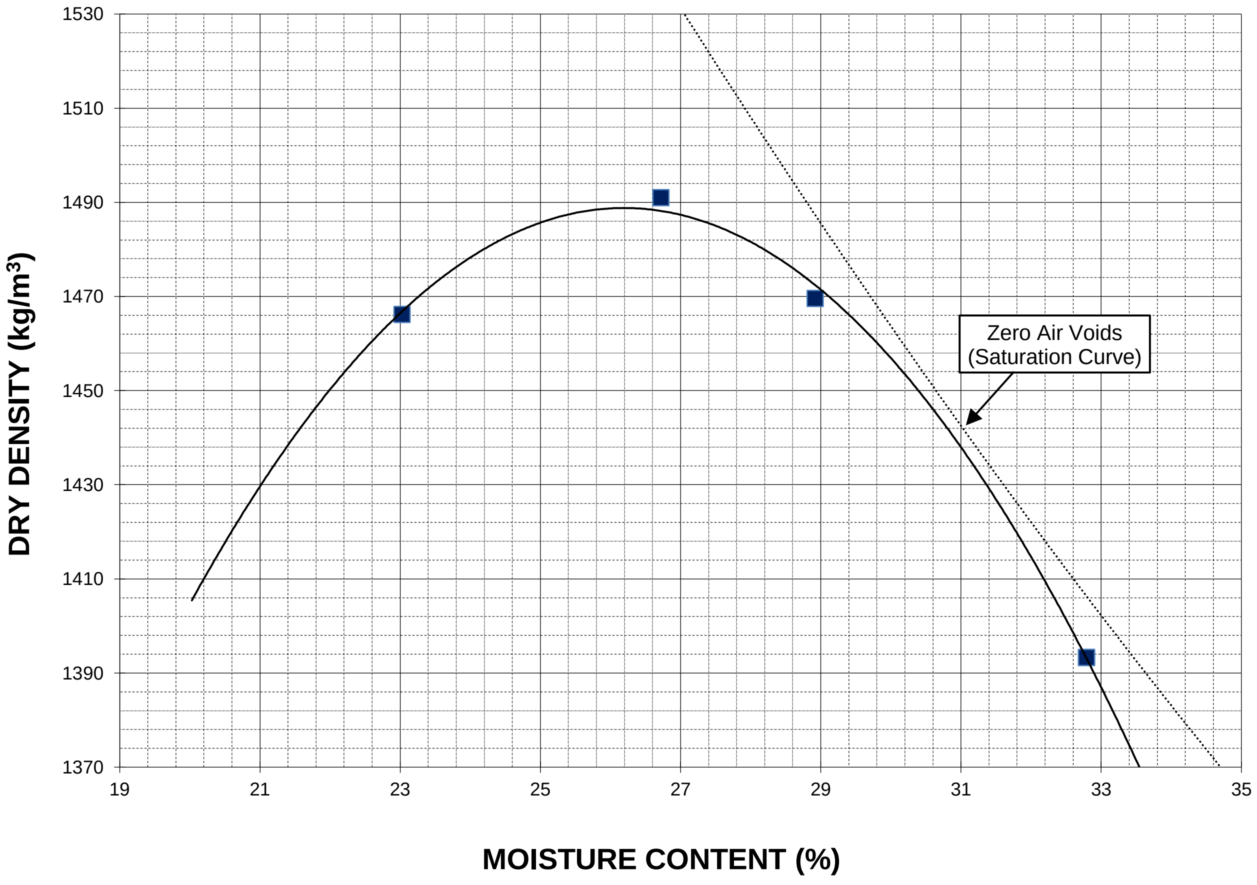
CERTIFIED BY CCIL
Canadian Council of Independent Laboratories
For specific tests as listed on www.ccil.com

Project No. 1000-043-22
Client WSP Canada Group Ltd.
Project 2023 Local and Industrial Streets Package (23-RI-02)

Sample # TH22-01 & TH22-02 (combined)
Source Panet Rd.
Material Clay
Sample Date 15-Nov-22
Test Date 23-Nov-22
Technician DS

Maximum Dry Density (kg/m3)	1489
Optimum Moisture (%)	26.2

Trial Number	1	2	3	4	
Wet Density (kg/m^3)	1804	1890	1895	1850	
Dry Density (kg/m^3)	1466	1491	1470	1393	
Moisture Content (%)	23.0	26.7	28.9	32.8	



Note: Additional information recorded/measured for this test is available upon request.

TREK GEOTECHNICAL
www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

California Bearing Ratio Test Data Sheet

ASTM D1883-16

Project No.	1000-043-22	**Source**	Panet Rd.
Client	WSP Canada Group Ltd.	**Material**	Clay
Project	2023 Local Streets (23-RI-02)	**Sample Date**	2022-11-15
Sample #	TH22-01 & TH22-02 (combined)	**Test Date**	2022-11-25
		Technician	DS

Proctor Results (ASTM D698)

Maximum Dry Density	1489	kg/m3
Optimum Moisture Content	26.2	%
Material Retained on 19 mm Sieve	0.0	%

CBR Sample Compaction

Dry Density	1409	kg/m3
Initial Moisture Content	25.6	%
Relative Density	94.6	% SPMDD

Soaking Results

Surcharge	4.54	kg
Swell	2.3	%
Moisture Content in top 25 mm	39.3	%
Immersion Period	96	h

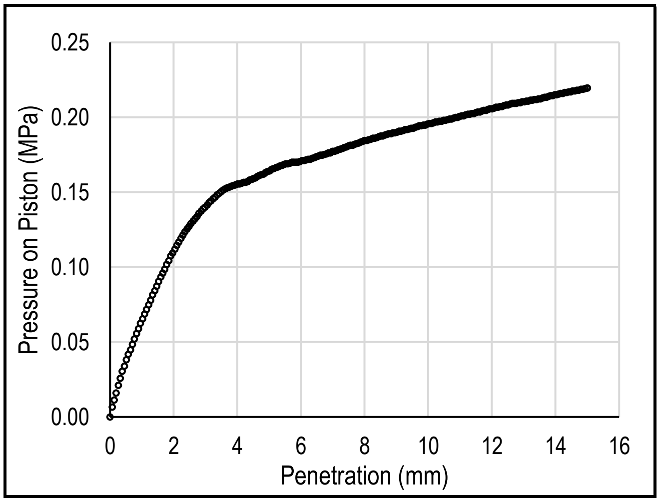
CBR Results

CBR at 2.54 mm	1.9	%
CBR at 5.08 mm	1.6	%
Zero Correction	0	mm

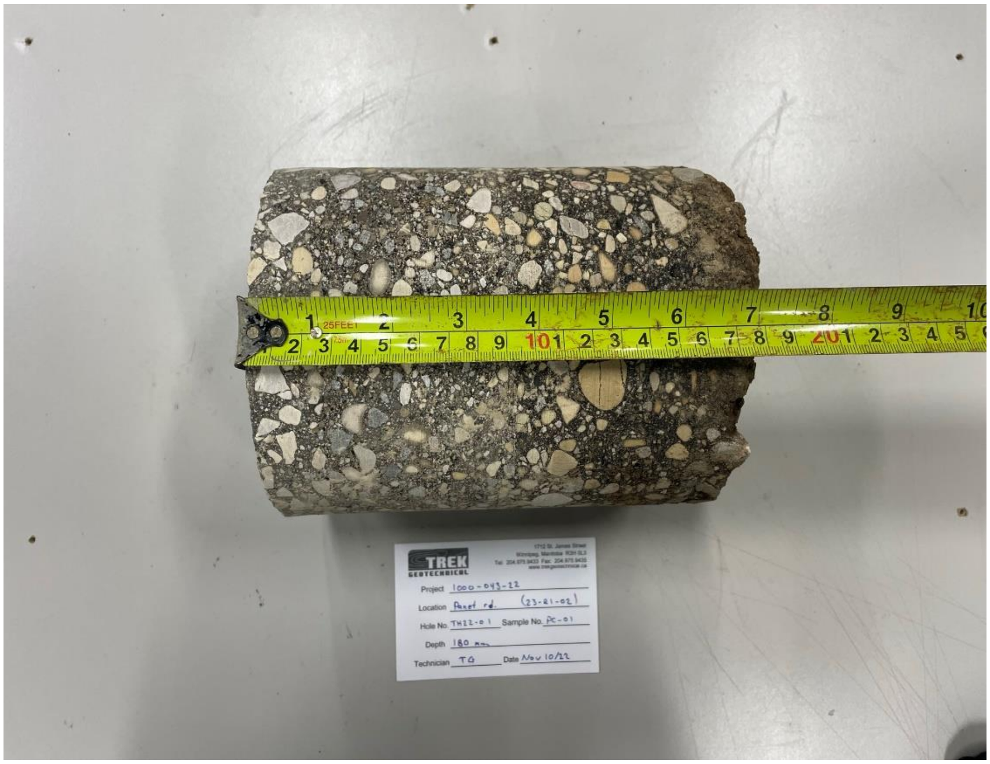
Test Data

Penetration (mm)	Measured Pressure (MPa)	Corrected Pressure (MPa)
0.64	0.05	0.05
1.27	0.08	0.08
1.91	0.11	0.11
2.54	0.13	0.13
3.18	0.14	0.14
3.81	0.15	0.15
4.45	0.16	0.16
5.08	0.17	0.17
7.62	0.18	0.18
10.16	0.20	0.20
12.70	0.21	0.21

Load/Penetration Curve



Comments:



1712 St. James Street
Winnipeg, Manitoba R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435
www.trekgeotechnical.ca

Project 1000-043-22
Location Panet rd. (23-RI-02)
Hole No. TH22-01 Sample No. PC-01
Depth 180 mm
Technician TG Date Nov 10/22

Photo 1: Pavement Core Sample at TH22-01

1712 St. James Street
Winnipeg, Manitoba R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435
www.trekgeotechnical.ca

Project 1000-043-22
Location Panet rd (23-RI-02)
Hole No. TH22-02 Sample No. PC02
Depth 200 mm
Technician TG Date Nov. 15/22

Photo 2: Pavement Core Sample at TH22-02

1712 St. James Street
Winnipeg, Manitoba R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435
www.trekgeotechnical.ca

Project 1000-043-22
Location Panet rd. (23-RI-02)
Hole No. TH22-03 Sample No. PC 03
Depth 120mm
Technician TG Date Nov. 15/22

Photo 3: Pavement Core Sample at TH22-03

TREK GEOTECHNICAL

2023 Local and Industrial Streets Renewal Package - 23-RI-02

Panet Rd - Narin Av / CPR Tracks

Pavement Core No.	Pavement Core Location	Pavement Surface		Pavement Structure Material		
		Type	Thickness (mm)	Type	Thickness (mm)	Corrected Compressive Strength (Mpa)
PC22-01	UTM: 14U 5528813 N, 638120 E; Located in front of #475 Panet Rd, 1.5 m West of East edge of road.	Asphalt	120	Concrete	110	-
PC22-02	UTM: 14U 5528925 N, 638219 E; Located in front of #481 Panet Rd, 2.1 m East of West edge of road.	Asphalt	85	Concrete	115	-
PC22-03	UTM: 14U 5529041N, 638338 E; Located in front of #435 Unit 2 Panet Rd, 0.4 m West of East edge of road.	Asphalt	120	Concrete	-	-
PC22-04	UTM: 14U 5529106 N, 638382 E; 1.6 m East of West edge of road.	Asphalt	-	Concrete	190	61
PC22-05	UTM: 14U 5529117 N, 638415 E; 1.8 m West of East edge of road.	Asphalt	-	Concrete	215	54.77

1712 St. James Street
Winnipeg, Manitoba R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435
www.trekgeotechnical.ca

Project 1000-043-22
Location Panet rd (23-RI-02)
Hole No. PC-04 Sample No. PC-04
Depth 190 mm
Technician TG Date Nov 10/22

Photo 1: Pavement Core Sample PC-04

1712 St. James Street
Winnipeg, Manitoba R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435
www.trekgeotechnical.ca

Project 1000-043-22
Location Panet rd. (23-RI-02)
Hole No. PC-05 Sample No. PC-05
Depth 215mm
Technician TG Date Nov 10/22

Photo 2: Pavement Core Sample PC-05

TREK GEOTECHNICAL
www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

Concrete Core Compressive Strength Report

CSA A23.2-14C

Project No. 1000-043-22

Project 2023 Local Streets Package - 23-R1-02

Client WSP Group Canada Inc.

Date December 14, 2022

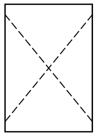
Technician KM

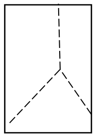
Core Location	Core ID	Date Received	Date of Break	Age at Break	Diam. (mm)	Length (mm)	Moisture Conditioning	Compressive Strength (MPa)		Break Type	Correction Factors*				
								Uncorrected f_{conc}	Corrected* f_c		$F_{l/d}$	F_{dia}	F_{mc}	F_D	F_{reinf}
*Panet Road	PC-04	2022-11-10	2022-12-14	-	145	186	Soaked 48 h	48.88	60.69	1	0.9506	0.9802	1.0900	1.0600	1.1531
Panet Road	PC-05	2022-11-10	2022-12-14	-	145	208	Soaked 48 h	45.93	54.77	1	0.9689	0.9802	1.0900	1.0600	1.0867

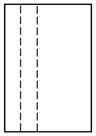
Comments

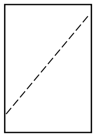
*Correction factors $F_{l/d}$, F_{dia}, F_{mc}, and F_D calculated as per ACI 214.4R-03, and correction factor F_{reinf} calculated as per Khoury et al. (2014): $f_c = f_{conc}F_{l/d}F_{dia}F_{mc}F_DF_{reinf}$

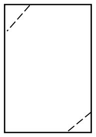
*PC-04 contained tie off rebar in specimen along with reinforcing rebar.

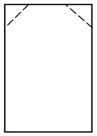

Type 1


Type 2


Type 3


Type 4


Type 5


Type 6

Reviewed by (print): Angela Fidler-Kliewer, C.Tech.

Signature: Angela Fidler-Kliewer

Table 1 Factors involved in interpretation of core results by different codes.

List	Code/standard	Edition	Factors Considered					
			Aspect ratio	Diameter	Reinforcing	Moisture	Damage	Direction
1	Egyptian Code/Standard Specification	2008	√		√			√
2	British Code/Standard Specification	2003	√		√			√
3	American Concrete Institute ACI	1998	√					
		2012	√	√		√	√	
4	European Standard Specification	1998	√	√	√		√	
		2009	√		√			
5	Japanese Standard	1998	√					
6	Concrete Society	1987	√		√		√	√

In addition, for core specimen containing two bars no further apart than the diameter of the larger bar, only the bar corresponding to the higher value of ($\Phi_r * d$) is considered. If the bars are further apart, their combined effect should be assessed by replacing the term ($\Phi_r * d$) by the term ($\sum \Phi_r * d$).

It should be pointed out that above equations used to interpret the core concrete strength to the in-situ concrete cube strength have been developed based on a set of assumptions and through many converting process. It is also of interest to note that the damage effect is considered in the development of the formulas in indirect way. The subject derivation and detailed formulas may be seen elsewhere [14].

3.2. American Concrete Institute (ACI)

3.2.1. Former ACI Code (2002) & Current ASTM (2009)

The methodology of core interpretation given in the former ACI code was remained without changes for decades and up to Year (2003). The in-place strength of concrete cylinder at the location from which a core test specimen was extracted can be computed using the equation:

$$f_{cy} = F_{l/d} \cdot f_{core} \tag{4}$$

where f_{cy} is the equivalent in-place concrete cylinder strength, f_{core} is concrete core strength, and $F_{l/d}$ is the strength correction factor for aspect ratio.

The former ACI code does not include any equation to calculate the correction factor ($F_{l/d}$); however, the code gives different values for this term that is associated with different aspect ratios (l/d) as given in Table 2. It should also be noted that the approach of current ASTM is similar to that mentioned above. The only considered variable is the aspect ratio (l/d). It should be noted that identical approach to that mentioned above is still effective in ASTM C42/C42M-03 [10].

3.2.2. Current ACI Code (2012) [15]

Starting from Year 2003, significant changes have been made to the relevant ACI Code provisions regarding the interpretation of core strength test results. New factors have been considered. These include core diameter, moisture content of core sample, core damage associated with drilling, in addition to the effect of aspect ratio that was previously considered in the former ACI edition (1998). According to the ACI 214.4R-03, the in-place concrete strength can be computed using the equation:

← eq. 12

$$f_c = F_{l/d} \cdot F_{dia} \cdot F_{mc} \cdot F_D \cdot f_{core} \cdot F_{reinf} \tag{5}$$

or eq. 15

where f_c is the equivalent in-place concrete cylinder strength, f_{core} is concrete core strength, $F_{l/d}$ is strength correction factor for aspect ratio, F_{dia} is strength correction factors for diameter, F_{mc} is strength correction factor for moisture condition of core sample, and F_D is the strength correction factor that accounts for effect of damage sustained during core drilling including micro-cracking and undulations at the drilled surface and cutting through coarse-aggregate particles that may subsequently pop out during testing.

The ACI committee considered the correction factors presented in Table 3 for converting core strengths into equivalent in-place strengths based on the work reported by Bartlett and MacGregor [6]. It should be noted that the magnitude of

Table 2 Mean values for factor $F_{l/d}$ according to ACI Code (1998) and ASTM.

	Specimen length-to-diameter ratio, l/d			
	1.00	1.25	1.50	1.75
$F_{l/d}$	0.87	0.93	0.96	0.98

Table 3 Strength correction factors according to ACI 214.4R-03.

List	Factors	Mean values
(1)[b]	$F_{l/d}$:l/d ratio	
	As-received	$1 - \{0.130 - \alpha f_{core}\}(2 - \frac{l}{d})^2$
	Soaked 48 h	$1 - \{0.117 - \alpha f_{core}\}(2 - \frac{l}{d})^2$
	Air dried[a]	$1 - \{0.144 - \alpha f_{core}\}(2 - \frac{l}{d})^2$
(2)	F_{dia}: core diameter	
	50 mm	1.06
	100 mm	1.00
	150 mm	0.98
(3)	F_{mc}: core moisture content	
	As-received	1.00
	Soaked 48 h	1.09
	Air dried[a]	0.96
(4)	F_D: damage due to drilling	1.06

[a] Standard treatment specified in ASTM C 42/C 42M.

[b] Constant α equals $4.3(10^{-4})$ 1/MPa for f_{core} in MPa.

Table 6 List of comparisons between tested cores to determine.

	A18	A17	A16	A15	A14	A13	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1
A1	♦●	●	♦●	■●	■●		●				●			▲	▲	■	▲	
A2																		
A3						■●				■●								
A4																		
A5																		
A6								■▲●	■▲●			■▲						
A7								■▲●	■▲●									
A8		●	♦	●	●													
A9																		
A10								■▲●										
A11																		
A12		●		●	●													
A13																		
A14		●		●														
A15		●																
A16	●♦																	
A17	♦																	
A18																		

● Diameter of steel bar.
▲ Distance of steel bar from nearly end of core.
■ Number of steel bars and spacing between bars.
♦ Distance of steel bar from vertical axis of specimen.

This brief review indicated that the various proposed relationships for correction factors are all nonlinear. It should be noted that the equations given by the Egyptian Code takes into account most variables that may affect the interpretation of the results; however, the code ignores the deterioration of steel–concrete bond that may occur and also the position of the reinforcement from vertical axis of core specimens.

Weighted nonlinear regression analysis has been performed to determine the factor (F_{reinf}) with the use of the software "SAS" package and "Data Fit." This shows that the correction factor for reinforcement (F_{reinf}) is given by the following expression:

- For cores containing a single bar:

single bar

$$F_{\text{reinf}} = \left[1 + 1.5\frac{[\Phi_r \times r + \Phi_r \times (S/10)]}{\Phi_c * L}\right] \times \frac{1.13}{f_{\text{core}}^{0.015}} \quad (12)$$

- For core specimen containing two bars no further apart than the diameter of the larger bar, only the bar corresponding to the higher value of ($\Phi_r * d$) is considered. If the bars are further apart, their combined effect is assessed by replacing the term ($\Phi_r * r$) by ($\sum \Phi_r * r$ as follows:

multiple bars

$$F_{\text{reinf}} = \left[1 + 1.5\frac{\sum[\Phi_r \times r + \Phi_r \times (S/10)]}{\Phi_c * L}\right] \times \frac{1.13}{f_{\text{core}}^{0.015}} \quad (13)$$

where F_{reinf} is the correction factor for reinforcement, Φ_r is the diameter of the reinforcement, Φ_c is the diameter of the concrete specimen, r is the distance of axis of bar from nearer end of specimen, S is the distance of axis of bar from axis of core specimen, L is the length of the specimen after end preparation by grinding or capping, and f_{core} is the concrete core strength (kg/cm^2).

6.1.6. *Effect of moisture condition of core*

Results of about 100 cores indicate that the strength of cores left to dry in air for 7 days is on average 13% greater than that of cores soaked at least 40 h before testing. The strength of cores with negligible moisture gradient and tested after cutting is found to be 7–9% larger than that of soaked cores as shown in Fig. 20. The authors strongly recommend to use a correction factor accounting for moisture condition (F_m) equals to 1.09 and 0.96, respectively, for cores tested after 48 h soaked in water and for those tested after 7 days dry in air.

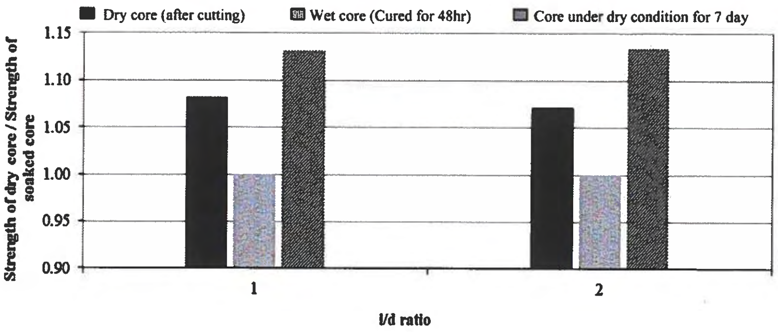


Figure 20 Effect of core moisture condition on core strength for different aspect ratios (l/d).

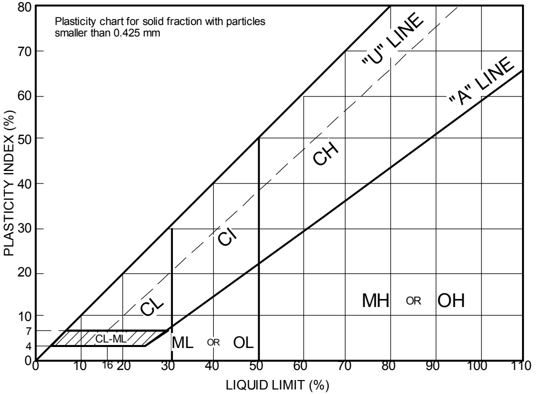
Appendix B

Test Hole Logs, Summary Table & Lab Testing Results and Pavement Core Photos - Panet Rd (between Dugald Rd and 45 Panet Rd)

EXPLANATION OF FIELD AND LABORATORY TESTING

GENERAL NOTES

1. Classifications are based on the United Soil Classification System and include consistency, moisture, and color. Field descriptions have been modified to reflect results of laboratory tests where deemed appropriate.
2. Descriptions on these test hole logs apply only at the specific test hole locations and at the time the test holes were drilled. Variability of soil and groundwater conditions may exist between test hole locations.
3. When the following classification terms are used in this report or test hole logs, the primary and secondary soil fractions may be visually estimated.

Major Divisions			USCS Classification	Symbols	Typical Names	Laboratory Classification Criteria		
Coarse-Grained soils (More than half the material is larger than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than 4.75 mm)	Clean gravel (Little or no fines)	GW	▩	Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain size curve, depending on percentage of fines (fraction smaller than No. 200 sieve) coarse-grained soils are classified as follows: Less than 5 percent...... GW, GP, SW, SP More than 12 percent...... GM, GC, SM, SC 6 to 12 percent...... Borderline case4s requiring dual symbols*	$C_U = \frac{D_{60}}{D_{10}}$ greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			GP	▢	Poorly-graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW	
		Gravel with fines (Appreciable amount of fines)	GM	▥	Silty gravels, gravel-sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are border-line cases requiring use of dual symbols
			GC	▧	Clayey gravels, gravel-sand-silt mixtures		Atterberg limits above "A" line or P.I. greater than 7	
	Sands (More than half of coarse fraction is smaller than 4.75 mm)	Clean sands (Little or no fines)	SW	∴	Well-graded sands, gravelly sands, little or no fines		$C_U = \frac{D_{60}}{D_{10}}$ greater than 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			SP	⁘	Poorly-graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM	▥	Silty sands, sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are border-line cases requiring use of dual symbols
			SC	▨	Clayey sands, sand-clay mixtures		Atterberg limits above "A" line or P.I. greater than 7	
Fine-Grained soils (More than half the material is smaller than No. 200 sieve size)	Silts and Clays (Liquid limit less than 50)		ML	▥	Inorganic silts and very fine sands, rock floor, silty or clayey fine sands or clayey silts with slight plasticity	Plasticity Chart 		
			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 distomaceous fine sandy or silty soils, organic silts			
			CH	▰	Inorganic clays of high plasticity, fat clays			
			OH	≋	Organic clays of medium to high plasticity, organic silts			
	Highly Organic Soils		Pt	⁂	Peat and other highly organic soils	Von Post Classification Limit	Strong colour or odour, and often fibrous texture	

Material		Particle Size	
		mm	ASTM Sieve sizes
Sand	Coarse	2.00 to 4.75	#10 to #4
	Medium	0.425 to 2.00	#40 to #10
	Fine	0.075 to 0.425	#200 to #40
Silt or Clay		< 0.075	< #200

Material		Particle Size	
		mm	ASTM Sieve Sizes
Boulders		> 300	> 12 in.
Cobbles		75 to 300	3 in. to 12 in.
Gravel	Coarse	19 to 75	3/4 in. to 3 in.
	Fine	4.75 to 19	#4 to 3/4 in.

* Borderline classifications used for soils possessing characteristics of two groups are designated by combinations of groups symbols. For example; GW-GC, well-graded gravel-sand mixture with clay binder.

Other Symbol Types

■	Asphalt	▧	Bedrock (undifferentiated)	▢	Cobbles
⁘	Concrete	▭	Limestone Bedrock	▩	Boulders and Cobbles
▦	Fill	☰	Cemented Shale	▥	Silt Till
		▤	Non-Cemented Shale	▨	Clay Till

EXPLANATION OF FIELD AND LABORATORY TESTING

LEGEND OF ABBREVIATIONS AND SYMBOLS

LL - Liquid Limit (%)
PL - Plastic Limit (%)
PI - Plasticity Index (%)
MC - Moisture Content (%)
SPT - Standard Penetration Test
RQD - Rock Quality Designation
Qu - Unconfined Compression
Su - Undrained Shear Strength
VW - Vibrating Wire Piezometer
SI - Slope Inclinometer

▽ Water Level at Time of Drilling

▼ Water Level at End of Drilling

⧨ Water Level After Drilling as Indicated on Test Hole Logs

FRACTION OF SECONDARY SOIL CONSTITUENTS ARE BASED ON THE FOLLOWING TERMINOLOGY

TERM	EXAMPLES	PERCENTAGE
and	and CLAY	35 to 50 percent
"y" or "ey"	clayey, silty	20 to 35 percent
some	some silt	10 to 20 percent
trace	trace gravel	1 to 10 percent

TERMS DESCRIBING CONSISTENCY OR COMPACTION CONDITION

The Standard Penetration Test blow count (N) of a non-cohesive soil can be related to compactness condition as follows:

Descriptive Terms	SPT (N) (Blows/300 mm)
Very loose	< 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	> 50

The Standard Penetration Test blow count (N) of a cohesive soil can be related to its consistency as follows:

Descriptive Terms	SPT (N) (Blows/300 mm)
Very soft	< 2
Soft	2 to 4
Firm	4 to 8
Stiff	8 to 15
Very stiff	15 to 30
Hard	> 30

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

Descriptive Terms	Undrained Shear Strength (kPa)
Very soft	< 12
Soft	12 to 25
Firm	25 to 50
Stiff	50 to 100
Very stiff	100 to 200
Hard	> 200

Sub-Surface Log

Test Hole TH22-06 (Panet Rd)

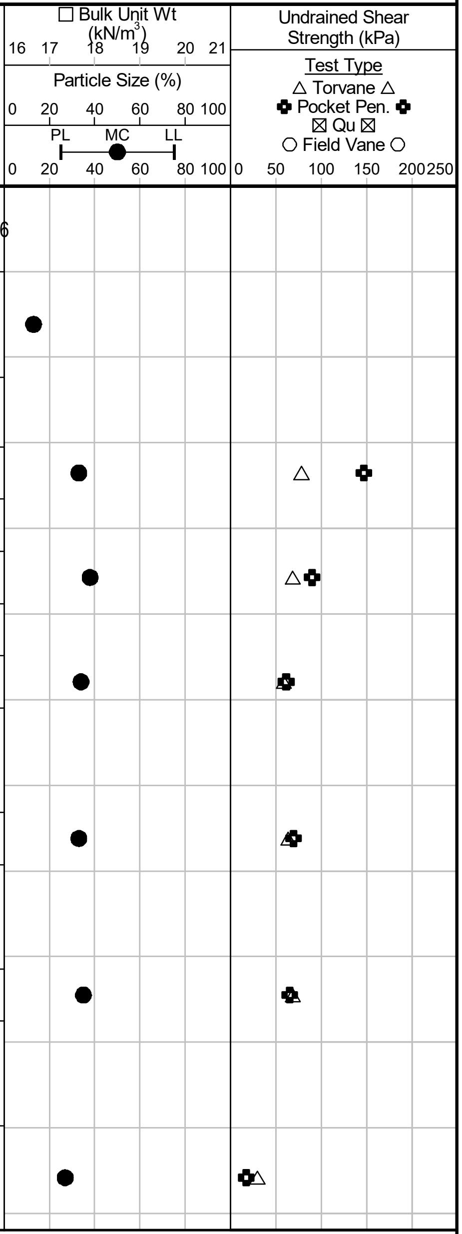
1 of 1

Client:	WSP Canada Group Ltd.	**Project Number:**	1000-043-22
Project Name:	2023 Local and Industrial Streets Renewal Package (23-RI-02)	**Location:**	UTM N-5527395, E-637776
Contractor:	Maple Leaf Drilling Ltd.	**Ground Elevation:**	Top of Pavement
Method:	125mm Solid Stem Auger, B40 Mobile Truck Mount	**Date Drilled:**	November 25, 2022

Sample Type: ◩ Grab (G) ▮ Shelby Tube (T) ☒ Split Spoon (SS) / SPT ☒ Split Barrel (SB) / LPT ▮ Core (C)

Particle Size Legend: ▦ Fines ▨ Clay ▥ Silt ⁙ Sand ● Gravel ◌ Cobbles ■ Boulders

Depth (m)	Soil Symbol	MATERIAL DESCRIPTION	Sample Type	Sample Number
0	■	ASPHALT - 250 mm thick	▮	PC22-06
	⁙●	SAND AND GRAVEL (FILL) - trace clay, trace silt, trace gravel (< 50 mm diam.) - brown - moist, compact - no to low plasticity, sub-rounded to angular crushed "pit run", AASHTO: A-1-b (I)	◩	G89
0.5	▨	CLAY - silty, trace sand, trace gravel (< 10 mm diam.) - black - moist, stiff to very stiff - high plasticity - AASHTO: A-7-6 (I)	◩	G90
1.0	▨	- stiff below 1.0 m	◩	G91
1.5	▨		◩	G92
	▨	- trace silt inclusions (< 50 mm diam.), brown below 1.8 m	◩	G93
2.0	▨			
2.5	▨		◩	G94
	▨	- some silt below 1.7 m	◩	G95
3.0				



END OF TEST HOLE AT 3.0 m IN CLAY.
1) Seepage or sloughing not observed.
2) Test hole dry and open to 3.0 m depth immediately after drilling.
3) Test hole backfilled with auger cuttings, bentonite chips and cold patch asphalt.
4) Test hole located in front of #35 Panet Rd, 0.5 m East of West edge of road.
5) The bulk sample was collected between 0.8 and 3.0 m depth.

Logged By: Jashandeep Singh Bhullar **Reviewed By:** Angela Fidler-Kliewer **Project Engineer:** Nelson Ferreira

TREK GEOTECHNICAL

Sub-Surface Log

Test Hole TH22-07 (Panet Rd)

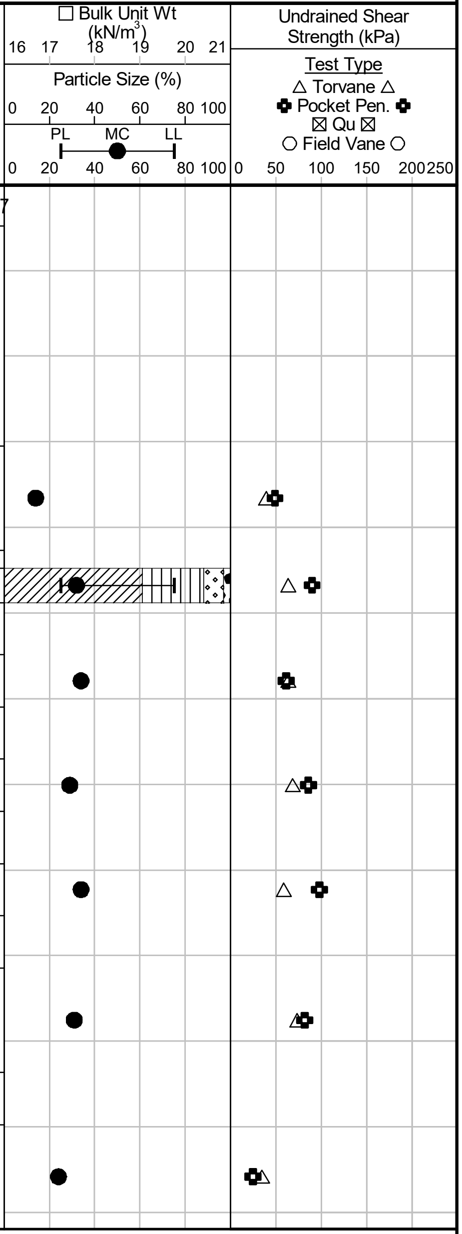
1 of 1

Client: WSP Canada Group Ltd.
Project Number: 1000-043-22
Project Name: 2023 Local and Industrial Streets Renewal Package (23-RI-02)
Location: UTM N-5527552, E-637904
Contractor: Maple Leaf Drilling Ltd.
Ground Elevation: Top of Pavement
Method: 125mm Solid Stem Auger, B40 Mobile Truck Mount
Date Drilled: November 25, 2022

Sample Type: ◣ Grab (G) ▮ Shelby Tube (T) ☒ Split Spoon (SS) / SPT ☒ Split Barrel (SB) / LPT ▮ Core (C)

Particle Size Legend: ▦ Fines ▨ Clay ▥ Silt ⁘ Sand ● Gravel ◌ Cobbles ■ Boulders

Depth (m)	Soil Symbol	MATERIAL DESCRIPTION	Sample Type	Sample Number
		ASPHALT - 120 mm thick	▮	PC22-07
0.5 1.0		CLAY (FILL) - silty, sandy, trace gravel (< 50 mm diam.) sub-rounded to angular - black - moist, stiff - high plasticity - AASHTO: A-7-6 (I)	◣	G82
1.5 2.0 2.5		CLAY - silty, trace silt inclusions (< 30 mm diam.) - grey - moist, stiff - high plasticity - AASHTO: A-7-6 (49) - brown below 1.7 m	◣ ◣ ◣ ◣ ◣	G83 G84 G85 G86 G87
3.0		SILT - clayey - brown - moist, soft - low plasticity, AASHTO: A-4 (I)	◣	G88



END OF TEST HOLE AT 3.0 m IN SILT.
1) Seepage or sloughing not observed.
2) Test hole dry and open to 3.0 m depth immediately after drilling.
3) Test hole backfilled with auger cuttings, bentonite chips and cold patch asphalt.
4) Test hole located in front of #405 Panet Rd, 2.2 m West of East edge of road.
5) The bulk sample was collected between 0.2 and 2.7 m depth.

Logged By: Jashandeep Singh Bhullar
Reviewed By: Angela Fidler-Kliewer
Project Engineer: Nelson Ferreira

Sub-Surface Log

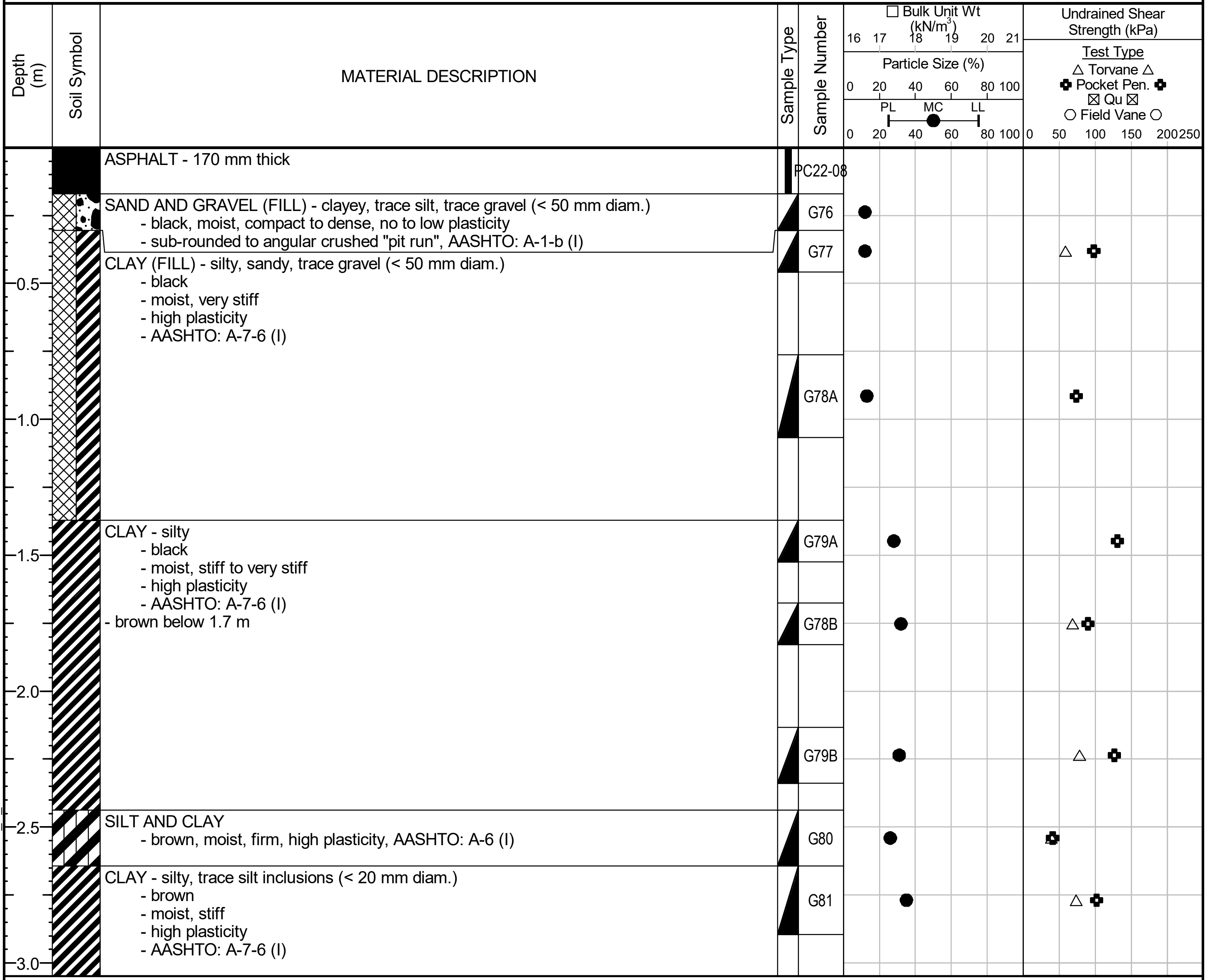
Test Hole TH22-08 (Panet Rd)

1 of 1

Client: WSP Canada Group Ltd.
Project Name: 2023 Local and Industrial Streets Renewal Package (23-RI-02)
Contractor: Maple Leaf Drilling Ltd.
Method: 125mm Solid Stem Auger, B40 Mobile Truck Mount
Project Number: 1000-043-22
Location: UTM N-5527645, E-637965
Ground Elevation: Top of Pavement
Date Drilled: November 25, 2022

Sample Type: Grab (G) | Shelby Tube (T) | Split Spoon (SS) / SPT | Split Barrel (SB) / LPT | Core (C)

Particle Size Legend: Fines | Clay | Silt | Sand | Gravel | Cobbles | Boulders



ASPHALT - 170 mm thick

SAND AND GRAVEL (FILL) - clayey, trace silt, trace gravel (< 50 mm diam.)
- black, moist, compact to dense, no to low plasticity
- sub-rounded to angular crushed "pit run", AASHTO: A-1-b (I)

CLAY (FILL) - silty, sandy, trace gravel (< 50 mm diam.)
- black
- moist, very stiff
- high plasticity
- AASHTO: A-7-6 (I)

CLAY - silty
- black
- moist, stiff to very stiff
- high plasticity
- AASHTO: A-7-6 (I)

- brown below 1.7 m

SILT AND CLAY
- brown, moist, firm, high plasticity, AASHTO: A-6 (I)

CLAY - silty, trace silt inclusions (< 20 mm diam.)
- brown
- moist, stiff
- high plasticity
- AASHTO: A-7-6 (I)

END OF TEST HOLE AT 3.0 m IN CLAY.
1) Seepage or sloughing not observed.
2) Test hole open dry and open to 3.0 m depth immediately after drilling.
3) Test hole backfilled with auger cuttings, bentonite chips and cold patch asphalt.
4) Test hole located in front of #110 Panet Rd, 1.2 m East of West edge of road.
5) The bulk sample was collected between 0.3 to 2.4 m and 2.7 to 3.0 m depth.

Logged By: Jashandeep Singh Bhullar
Reviewed By: Angela Fidler-Kliewer
Project Engineer: Nelson Ferreira

2023 Local and Industrial Streets Renewal Project - 23-RI-02
Sub-Surface Investigation
Panet Rd - Dugald Rd / 45 Panet Rd

Test Hole No.	Test Hole Location	Pavement Surface		Pavement Structure Material		Subgrade Description	Sample Depth (m)		Moisture Content (%)	Grain Size Analysis				Atterberg Limits		
		Type	Thickness (mm)	Type	Thickness (mm)		Top (m)	Bottom (m)		Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Plastic	Liquid	Plasticity Index
TH22-06	UTM: 14U 5527395 N, 637776 E Located in front of #35 Panet Rd, 0.5 m East of West edge of road.	Asphalt	250	Concrete	-	Sand and Gravel (Fill); AASHTO: A-1-b (I)	0.3	0.6	13							
						Clay; AASHTO: A-7-6 (I)	0.8	0.9	33							
						Clay; AASHTO: A-7-6 (I)	1.1	1.2	38							
						Clay; AASHTO: A-7-6 (I)	1.4	1.5	34							
						Clay; AASHTO: A-7-6 (I)	1.8	2.0	33							
						Clay; AASHTO: A-7-6 (I)	2.3	2.4	35							
						Clay; AASHTO: A-7-6 (I)	2.7	3.0	27							
TH22-07	UTM: 14U 5527552 N, 637904 E Located in front of #405 Panet Rd, 2.2 m West of East edge of road.	Asphalt	120	Concrete	-	Clay (Fill); AASHTO: A-7-6 (I)	0.8	1.1	14							
						Clay; AASHTO: A-7-6 (49)	1.1	1.2	32	61	27	9	3	25	75	50
						Clay; AASHTO: A-7-6 (49)	1.4	1.5	34							
						Clay; AASHTO: A-7-6 (49)	1.7	1.8	29							
						Clay; AASHTO: A-7-6 (49)	2.0	2.1	34							
						Clay; AASHTO: A-7-6 (49)	2.3	2.6	31							
						Silt; AASHTO: A-4 (I)	2.7	3.0	24							
TH22-08	UTM: 14U 5527645 N, 637965 E Located in front of #110 Panet Rd, 1.2 m East of West edge of road.	Asphalt	170	Concrete	-	Sand and Gravel (Fill); AASHTO: A-1-b (I)	0.2	0.3	12							
						Clay (Fill); AASHTO: A-7-6 (I)	0.3	0.5	12							
						Clay (Fill); AASHTO: A-7-6 (I)	0.8	1.1	13							
						Clay; AASHTO: A-7-6 (I)	1.4	1.5	28							
						Clay; AASHTO: A-7-6 (I)	1.7	1.8	32							
						Clay; AASHTO: A-7-6 (I)	2.1	2.3	31							
						Silt and Clay; AASHTO: A-6 (I)	2.4	2.6	26							
						Clay; AASHTO: A-7-6 (I)	2.6	2.9	35							

(I) - AASHTO classification was interpreted based on visual classification.

TREK GEOTECHNICAL
www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

Moisture Content Report
ASTM D2216-10

Project No.	1000-043-22
Client	WSP Canada Group LTD
Project	2023 Local and Industrial Streets Package (23-RI-02) - Panet Rd.
Sample Date	25-Nov-22
Test Date	29-Nov-22
Technician	TR

Test Hole	TH22-06	TH22-06	TH22-06	TH22-06	TH22-06	TH22-06
Depth (m)	0.2 - 0.5	0.8 - 0.9	1.1 - 1.2	1.4 - 1.5	1.8 - 2.0	2.3 - 2.4
Sample #	G89	G90	G91	G92	G93	G94
Tare ID	W69	Z68	K34	W27	C13	Z21
Mass of tare	8.5	8.5	8.6	8.3	8.4	8.5
Mass wet + tare	279.7	222.1	234.7	256.2	226.5	247.5
Mass dry + tare	248.2	169.0	173.0	193.4	172.8	185.0
Mass water	31.5	53.1	61.7	62.8	53.7	62.5
Mass dry soil	239.7	160.5	164.4	185.1	164.4	176.5
Moisture %	13.1%	33.1%	37.5%	33.9%	32.7%	35.4%

Test Hole	TH22-06	TH22-07	TH22-07	TH22-07	TH22-07	TH22-07
Depth (m)	2.7 - 3.0	0.8 - 1.1	1.1 - 1.2	1.4 - 1.5	1.7 - 1.8	2.0 - 2.1
Sample #	G95	G82	G83	G84	G85	G86
Tare ID	AA15	H29	W14	Z99	N84	F105
Mass of tare	6.9	7.4	8.6	8.4	8.6	8.5
Mass wet + tare	208.4	218.9	217.8	221.2	224.2	250.9
Mass dry + tare	165.1	193.2	166.9	166.7	176.3	189.3
Mass water	43.3	25.7	50.9	54.5	47.9	61.6
Mass dry soil	158.2	185.8	158.3	158.3	167.7	180.8
Moisture %	27.4%	13.8%	32.2%	34.4%	28.6%	34.1%

Test Hole	TH22-07	TH22-07	TH22-08	TH22-08	TH22-08	TH22-08
Depth (m)	2.3 - 2.6	2.7 - 3.0	0.2 - 0.3	0.3 - 0.5	0.8 - 1.1	1.4 - 1.5
Sample #	G87	G88	G76	G77	G78A	G79A
Tare ID	H80	N41	D34	N112	AB100	W25
Mass of tare	8.7	8.5	8.7	8.4	7.0	8.4
Mass wet + tare	237.6	210.7	223.6	238.4	219.6	197.7
Mass dry + tare	183.8	171.8	200.8	214.1	195.4	156.3
Mass water	53.8	38.9	22.8	24.3	24.2	41.4
Mass dry soil	175.1	163.3	192.1	205.7	188.4	147.9
Moisture %	30.7%	23.8%	11.9%	11.8%	12.8%	28.0%

www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

Moisture Content Report
ASTM D2216-10

Project No.	1000-043-22
Client	WSP Canada Group LTD
Project	2023 Local and Industrial Streets Package (23-RI-02) - Panet Rd.

Sample Date	25-Nov-22
Test Date	29-Nov-22
Technician	TR

Test Hole	TH22-08	TH22-08	TH22-08	TH22-08		
Depth (m)	1.7 - 1.8	2.1 - 2.3	2.4 - 2.7	2.7 - 2.9		
Sample #	G78B	G79B	G80	G81		
Tare ID	Z103	AB09	Z90	Z23		
Mass of tare	8.7	6.9	8.5	8.7		
Mass wet + tare	218.0	234.3	255.2	220.1		
Mass dry + tare	167.9	180.5	204.9	165.6		
Mass water	50.1	53.8	50.3	54.5		
Mass dry soil	159.2	173.6	196.4	156.9		
Moisture %	31.5%	31.0%	25.6%	34.7%		

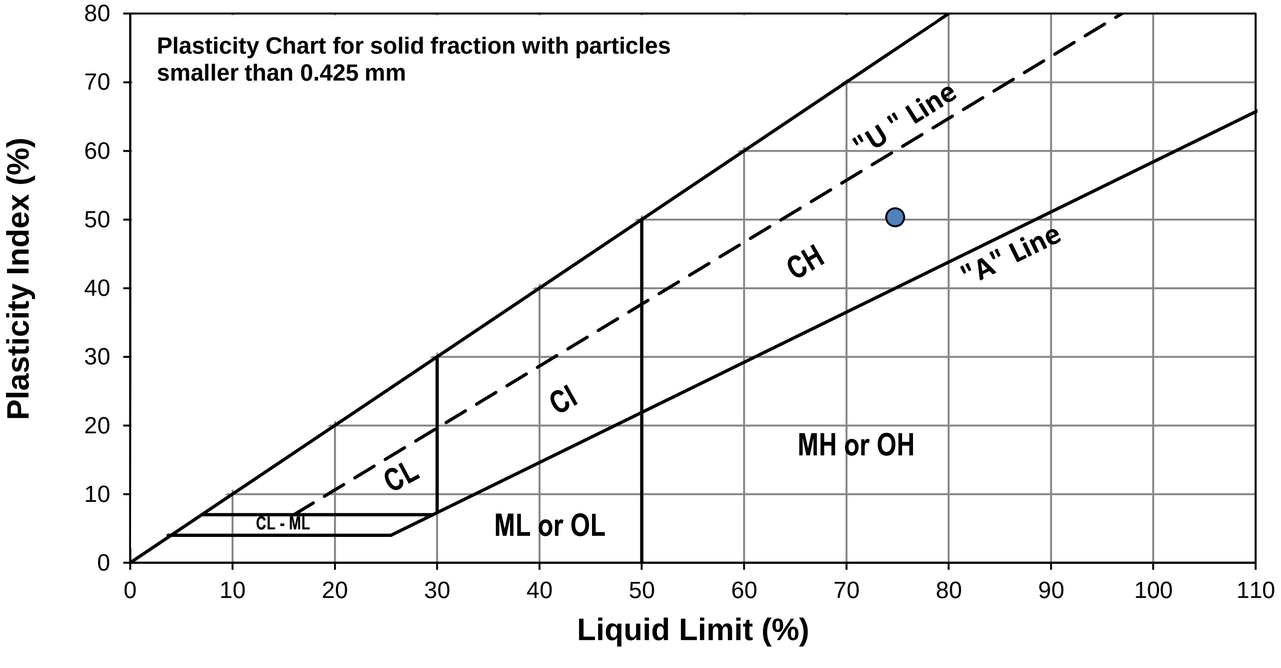
Atterberg Limits
ASTM D4318-10e1

Project No.	1000-043-22
Client	WSP Canada Group Ltd.
Project	2023 Local and Industrial Streets Renewal Package (23-RI-02)
Test Hole	TH22-07
Sample #	G83
Depth (m)	1.1 - 1.2
Sample Date	25-Nov-22
Test Date	06-Dec-22
Technician	MT

Liquid Limit	75
Plastic Limit	25
Plasticity Index	50

Liquid Limit

Trial #	1	2	3		
Number of Blows (N)	21	27	31		
Mass Tare (g)	14.221	14.237	14.128		
Mass Wet Soil + Tare (g)	25.607	23.458	23.838		
Mass Dry Soil + Tare (g)	20.681	19.532	19.742		
Mass Water (g)	4.926	3.926	4.096		
Mass Dry Soil (g)	6.460	5.295	5.614		
Moisture Content (%)	76.254	74.145	72.960		



Plastic Limit

Trial #	1	2	3	4	5
Mass Tare (g)	14.209	14.112			
Mass Wet Soil + Tare (g)	24.852	25.070			
Mass Dry Soil + Tare (g)	22.753	22.918			
Mass Water (g)	2.099	2.152			
Mass Dry Soil (g)	8.544	8.806			
Moisture Content (%)	24.567	24.438			

Note: Additional information recorded/measured for this test is available upon request.

TREK GEOTECHNICAL
www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

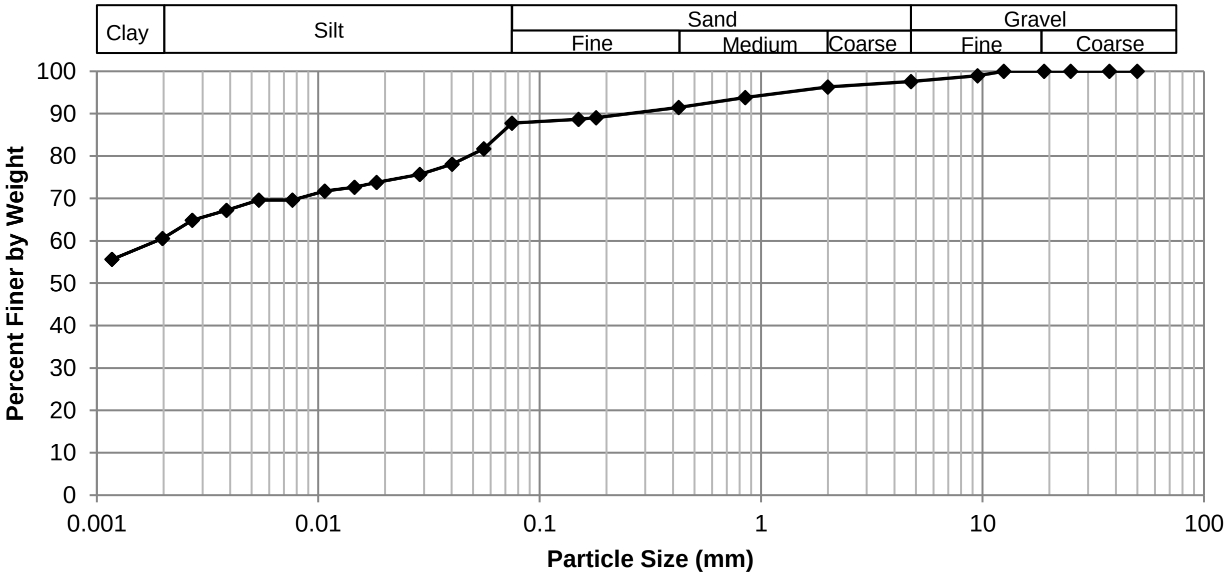
Grain Size Analysis (Hydrometer Method)
AASHTO T 88

CERTIFIED BY CCIL
Canadian Council of Independent Laboratories
For specific tests as listed on www.ccil.com

Project No.	1000-043-22
Client	WSP Canada Group Ltd.
Project	2023 Local Street and Industrial Package (23-RI-02) Panet Rd
Test Hole	TH22-07
Sample #	G83
Depth (m)	1.1 - 1.2
Sample Date	25-Nov-22
Test Date	5-Dec-22
Technician	DS

Gravel	2.4%
Sand	9.8%
Silt	27.1%
Clay	60.7%

Particle Size Distribution Curve



Gravel		Sand		Silt and Clay	
Particle Size (mm)	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**
50.0	100.00	4.75	97.58	0.0750	87.75
37.5	100.00	2.00	96.30	0.0560	81.70
25.0	100.00	0.850	93.85	0.0403	78.08
19.0	100.00	0.425	91.49	0.0288	75.67
12.5	100.00	0.180	89.06	0.0184	73.82
9.50	98.99	0.150	88.71	0.0146	72.66
4.75	97.58	0.075	87.75	0.0107	71.72
				0.0076	69.61
				0.0054	69.65
				0.0039	67.24
				0.0027	64.88
				0.0020	60.58
				0.0012	55.63

TREK GEOTECHNICAL
www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

Standard Proctor Compaction Test

ASTM D698-12 (2021)

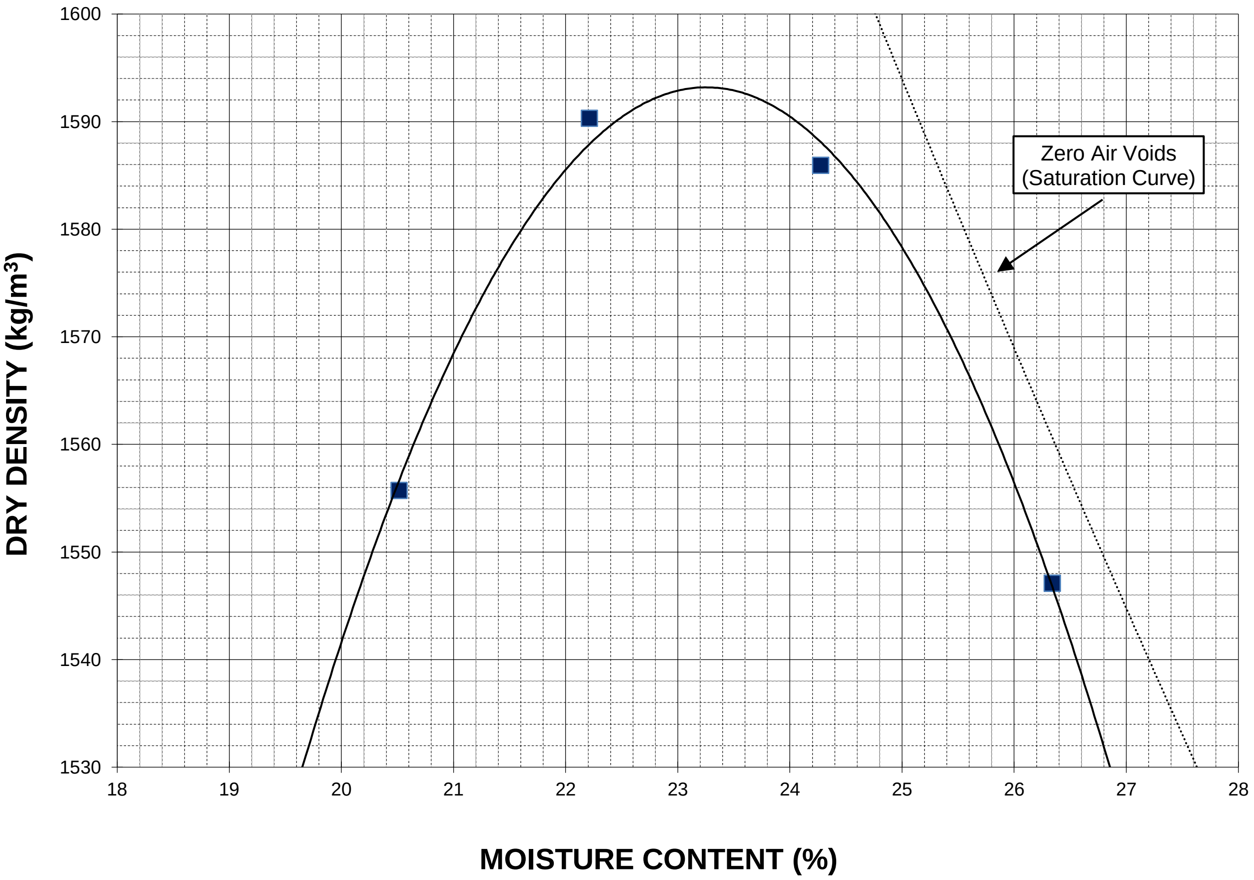
CERTIFIED BY CCIL Canadian Council of Independent Laboratories For specific tests as listed on www.ccil.com

Project No. 1000-043-22
Client WSP Canada Group LTD
Project 2023 Local and Industrial Streets Package (23-RI-02)

Sample # TH22-07 & TH22-08 (combined)
Source Panet Rd.
Material Clay
Sample Date 20-Nov-22
Test Date 02-Dec-22
Technician JC

Maximum Dry Density (kg/m3)	1593
Optimum Moisture (%)	23.3

Trial Number	1	2	3	4	
Wet Density (kg/m^3)	1875	1944	1971	1955	
Dry Density (kg/m^3)	1556	1590	1586	1547	
Moisture Content (%)	20.5	22.2	24.3	26.3	



Note: Additional information recorded/measured for this test is available upon request.

www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

California Bearing Ratio Test Data Sheet

ASTM D1883-16

Project No.	1000-043-22	**Source**	Panet Road
Client	WSP Canada Group Ltd.	**Material**	Clay
Project	2023 Local Streets Renewal (23-RI-02)	**Sample Date**	2022-11-25
Sample #	TH22-07 & TH22-08 (combined)	**Test Date**	2022-12-05
		Technician	JC

Proctor Results (ASTM D698)

Maximum Dry Density	1598	kg/m3
Optimum Moisture Content	23.2	%
Material Retained on 19 mm Sieve	0.0	%

CBR Sample Compaction

Dry Density	1532	kg/m3
Initial Moisture Conte	22.1	%
Relative Density	95.8	% SPMDD

Soaking Results

Surcharge	4.54	kg
Swell	1.9	%
Moisture Content in top 25 mm	37.3	%
Immersion Period	96	h

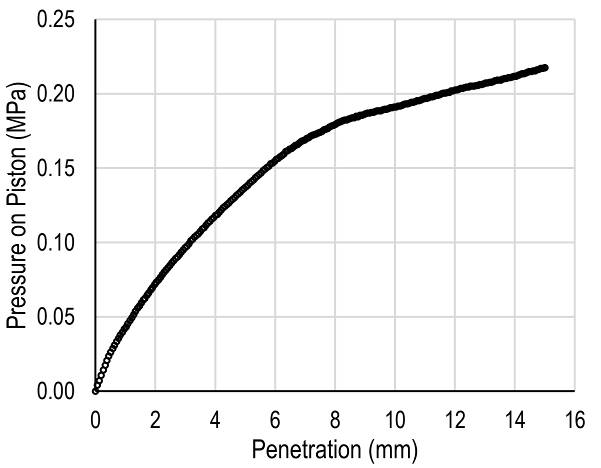
CBR Results

CBR at 2.54 mm	1.3	%
CBR at 5.08 mm	1.3	%
Zero Correction	0	mm

Test Data

Penetration (mm)	Measured Pressure (MPa)	Corrected Pressure (MPa)
0.64	0.03	0.03
1.27	0.05	0.05
1.91	0.07	0.07
2.54	0.09	0.09
3.18	0.10	0.10
3.81	0.11	0.11
4.45	0.13	0.13
5.08	0.14	0.14
7.62	0.18	0.18
10.16	0.19	0.19
12.70	0.21	0.21

Load/Penetration Curve



Comments:

Template Rev. B - 2018-04-07

TREK GEOTECHNICAL

Project 1000-043-22

Location Panet rd (23-RI-02)

Hole No. TH22-06 Sample No. PC-06

Depth 250mm

Technician TG Date Nov 10/22

Photo 4: Pavement Core Sample at TH22-06

TREK GEOTECHNICAL

Project 1000-043-22

Location Panet road (23-RI-02)

Hole No. TH22-07 Sample No. PC 07

Depth 230mm

Technician TG Date Nov 15/22

Photo 5: Pavement Core Sample at TH225-07

Photo 3: Pavement Core Sample at TH22-08

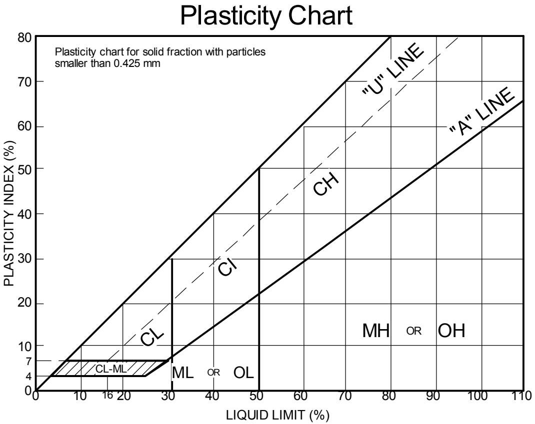
Appendix C

Test Hole Logs, Summary Table & Lab Testing Results and Pavement Core Photos – Springfield Rd.

EXPLANATION OF FIELD AND LABORATORY TESTING

GENERAL NOTES

1. Classifications are based on the United Soil Classification System and include consistency, moisture, and color. Field descriptions have been modified to reflect results of laboratory tests where deemed appropriate.
2. Descriptions on these test hole logs apply only at the specific test hole locations and at the time the test holes were drilled. Variability of soil and groundwater conditions may exist between test hole locations.
3. When the following classification terms are used in this report or test hole logs, the primary and secondary soil fractions may be visually estimated.

Major Divisions			USCS Classi-fication	Symbols	Typical Names	Laboratory Classification Criteria		
Coarse-Grained soils (More than half the material is larger than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than 4.75 mm)	Clean gravel (Little or no fines)	GW	▚	Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain size curve, depending on percentage of fines (fraction smaller than No. 200 sieve) coarse-grained soils are classified as follows: Less than 5 percent....... GW, GP, SW, SP More than 12 percent....... GM, GC, SM, SC 6 to 12 percent....... Borderline case4s requiring dual symbols*	$C_U = \frac{D_{60}}{D_{10}}$ greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			GP	◌	Poorly-graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW	
		Gravel with fines (Appreciable amount of fines)	GM	▥	Silty gravels, gravel-sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are border-line cases requiring use of dual symbols
			GC	▩	Clayey gravels, gravel-sand-silt mixtures		Atterberg limits above "A" line or P.I. greater than 7	
	Sands (More than half of coarse fraction is smaller than 4.75 mm)	Clean sands (Little or no fines)	SW	⁘	Well-graded sands, gravelly sands, little or no fines		$C_U = \frac{D_{60}}{D_{10}}$ greater than 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			SP	░	Poorly-graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM	▥	Silty sands, sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are border-line cases requiring use of dual symbols
			SC	▨	Clayey sands, sand-clay mixtures		Atterberg limits above "A" line or P.I. greater than 7	
Fine-Grained soils (More than half the material is smaller than No. 200 sieve size)	Silts and Clays (Liquid limit less than 50)		ML	▥	Inorganic silts and very fine sands, rock floor, silty or clayey fine sands or clayey silts with slight plasticity	Plasticity Chart 		
			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 distomaceous fine sandy or silty soils, organic silts			
			CH	▨	Inorganic clays of high plasticity, fat clays			
			OH	≋	Organic clays of medium to high plasticity, organic silts			
	Highly Organic Soils		Pt	⁂	Peat and other highly organic soils	Von Post Classification Limit	Strong colour or odour, and often fibrous texture	

Material		Particle Size	
		mm	ASTM Sieve sizes
Sand	Coarse	2.00 to 4.75	#10 to #4
	Medium	0.425 to 2.00	#40 to #10
	Fine	0.075 to 0.425	#200 to #40
Silt or Clay		< 0.075	< #200

Material		Particle Size	
		mm	ASTM Sieve Sizes
Boulders		> 300	> 12 in.
Cobbles		75 to 300	3 in. to 12 in.
Gravel	Coarse	19 to 75	3/4 in. to 3 in.
	Fine	4.75 to 19	#4 to 3/4 in.

* Borderline classifications used for soils possessing characteristics of two groups are designated by combinations of groups symbols. For example; GW-GC, well-graded gravel-sand mixture with clay binder.

Other Symbol Types

■	Asphalt	▧	Bedrock (undifferentiated)	◌	Cobbles
░	Concrete	▦	Limestone Bedrock	▚	Boulders and Cobbles
▩	Fill	▤	Cemented Shale	▥	Silt Till
		▨	Non-Cemented Shale	▩	Clay Till

EXPLANATION OF FIELD AND LABORATORY TESTING

LEGEND OF ABBREVIATIONS AND SYMBOLS

LL - Liquid Limit (%)
PL - Plastic Limit (%)
PI - Plasticity Index (%)
MC - Moisture Content (%)
SPT - Standard Penetration Test
RQD - Rock Quality Designation
Qu - Unconfined Compression
Su - Undrained Shear Strength
VW - Vibrating Wire Piezometer
SI - Slope Inclinometer

▽ Water Level at Time of Drilling

▼ Water Level at End of Drilling

⧩ Water Level After Drilling as Indicated on Test Hole Logs

FRACTION OF SECONDARY SOIL CONSTITUENTS ARE BASED ON THE FOLLOWING TERMINOLOGY

TERM	EXAMPLES	PERCENTAGE
and	and CLAY	35 to 50 percent
"y" or "ey"	clayey, silty	20 to 35 percent
some	some silt	10 to 20 percent
trace	trace gravel	1 to 10 percent

TERMS DESCRIBING CONSISTENCY OR COMPACTION CONDITION

The Standard Penetration Test blow count (N) of a non-cohesive soil can be related to compactness condition as follows:

Descriptive Terms	SPT (N) (Blows/300 mm)
Very loose	< 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	> 50

The Standard Penetration Test blow count (N) of a cohesive soil can be related to its consistency as follows:

Descriptive Terms	SPT (N) (Blows/300 mm)
Very soft	< 2
Soft	2 to 4
Firm	4 to 8
Stiff	8 to 15
Very stiff	15 to 30
Hard	> 30

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

Descriptive Terms	Undrained Shear Strength (kPa)
Very soft	< 12
Soft	12 to 25
Firm	25 to 50
Stiff	50 to 100
Very stiff	100 to 200
Hard	> 200

Sub-Surface Log

Test Hole TH22-17 (Springfield Rd)

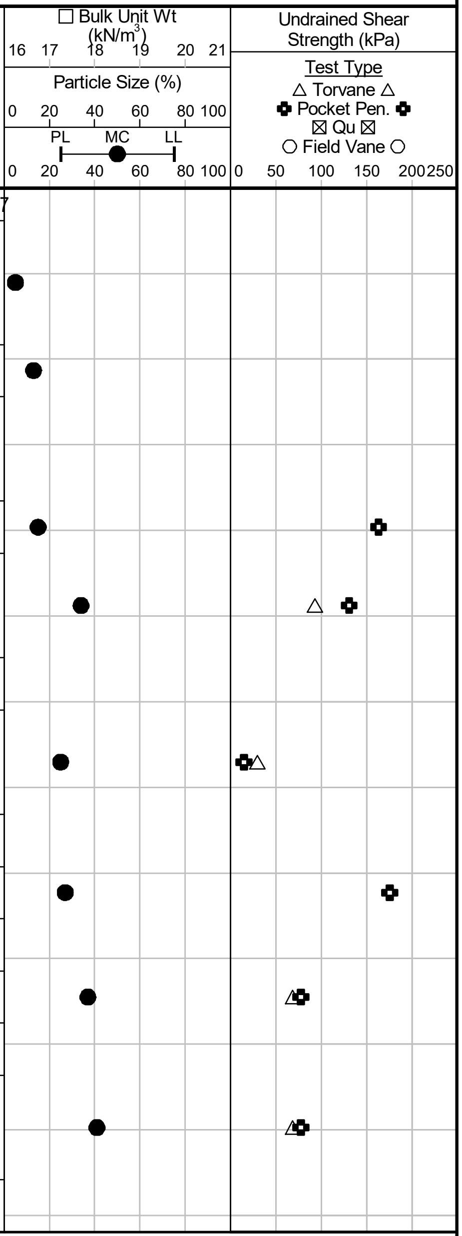
1 of 1

Client: WSP Canada Group Ltd.
Project Name: 2023 Local and Industrial Streets Renewal Package (23-RI-02)
Contractor: Maple Leaf Drilling Ltd.
Method: 125mm Solid Stem Auger, B40 Mobile Truck Mount
Project Number: 1000-043-22
Location: UTM N-5532780, E-640485
Ground Elevation: Top of Pavement
Date Drilled: November 15, 2022

Sample Type: Grab (G) | Shelby Tube (T) | Split Spoon (SS) / SPT | Split Barrel (SB) / LPT | Core (C)

Particle Size Legend: Fines | Clay | Silt | Sand | Gravel | Cobbles | Boulders

Depth (m)	MATERIAL DESCRIPTION	Sample Type	Sample Number
	ASPHALT - 95 mm thick	Core	PC22-17
	SAND AND GRAVEL (FILL) - trace silt, trace gravel (<50 mm diam.) - brown - frozen, moist and compact when thawed - sub-rounded to angular crushed "pit run", AASHTO: A-1-b (I)	Grab	G96
0.5	CLAY (FILL) - silty, trace sand, trace gravel (< 50 diam.) - black - frozen to 0.9 m, moist and very stiff when thawed - high plasticity - AASHTO: A-7-6 (I)	Grab	G97
1.0		Grab	G98
	CLAY - silty - grey - moist, very stiff - high plasticity - AASHTO: A-7-6 (I)	Grab	G99
1.5	SILT - clayey - brown - moist, firm - low plasticity, AASHTO: A-4 (I)	Grab	G100
2.0	CLAY - silty - brown - moist, very stiff - high plasticity - AASHTO: A-7-6 (I)	Grab	G101
	- stiff below 2.3 m	Grab	G102
2.5		Grab	G103
3.0			



END OF TEST HOLE AT 3.0 m IN CLAY.
1) Seepage or sloughing not observed.
2) Test hole dry and open to 3.0 m depth immediately after drilling.
3) Test hole backfilled with auger cuttings, bentonite chips and cold patch asphalt.
4) Test hole located in front of #1100 Springfield Rd, 1.4 m North of South edge of road.
5) The bulk sample was collected between 0.4 to 1.5 m and 1.8 to 3.0 m depth.

Logged By: Jashandeep Singh Bhullar
Reviewed By: Angela Fidler-Kliewer
Project Engineer: Nelson Ferreira

Sub-Surface Log

Test Hole TH22-18 (Springfield Rd)

1 of 1

Client: WSP Canada Group Ltd.

Project Name: 2023 Local and Industrial Streets Renewal Package (23-RI-02)

Contractor: Maple Leaf Drilling Ltd.

Method: 125mm Solid Stem Auger, B40 Mobile Truck Mount

Project Number: 1000-043-22

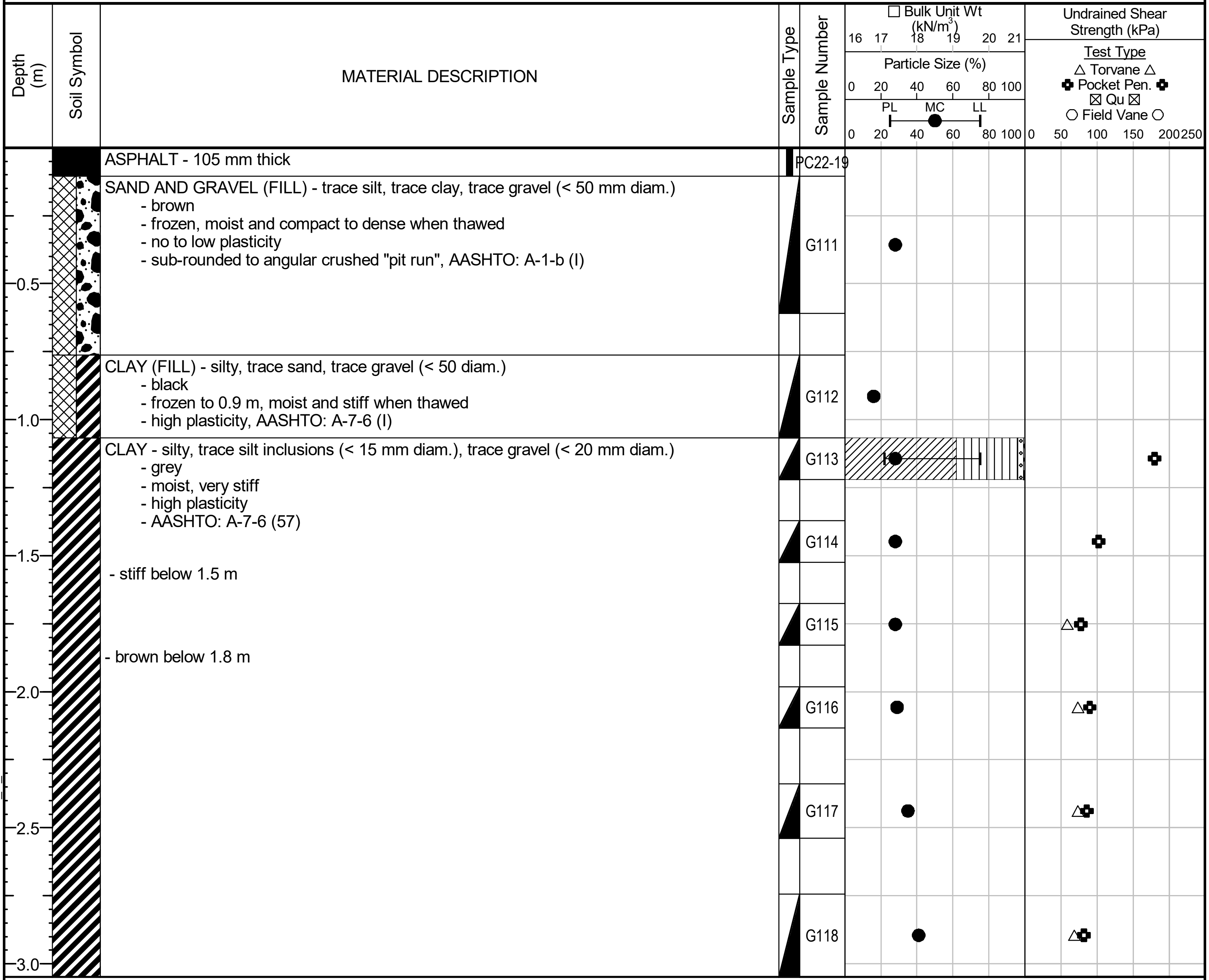
Location: UTM N-5532792, E-641817

Ground Elevation: Top of Pavement

Date Drilled: November 15, 2022

Sample Type: ◩ Grab (G) ▮ Shelby Tube (T) ☒ Split Spoon (SS) / SPT ⧗ Split Barrel (SB) / LPT ▯ Core (C)

Particle Size Legend: ▦ Fines ▨ Clay ▥ Silt ⁙ Sand ● Gravel ◌ Cobbles ■ Boulders



ASPHALT - 105 mm thick

SAND AND GRAVEL (FILL) - trace silt, trace clay, trace gravel (< 50 mm diam.)
- brown
- frozen, moist and compact to dense when thawed
- no to low plasticity
- sub-rounded to angular crushed "pit run", AASHTO: A-1-b (I)

CLAY (FILL) - silty, trace sand, trace gravel (< 50 diam.)
- black
- frozen to 0.9 m, moist and stiff when thawed
- high plasticity, AASHTO: A-7-6 (I)

CLAY - silty, trace silt inclusions (< 15 mm diam.), trace gravel (< 20 mm diam.)
- grey
- moist, very stiff
- high plasticity
- AASHTO: A-7-6 (57)

- stiff below 1.5 m

- brown below 1.8 m

END OF TEST HOLE AT 3.0 m IN CLAY.
1) Seepage or sloughing not observed.
2) Test hole open dry and open to 3.0 m depth immediately after drilling.
3) Test hole backfilled with auger cuttings, bentonite chips and cold patch asphalt.
4) Test hole located in front of #1100-1180 Springfield Rd, 1.1 m South of North edge of road.
5) The bulk sample was collected between 0.8 and 3.0 m depth.

Logged By: Jashandeep Singh Bhullar **Reviewed By:** Angela Fidler-Kliewer **Project Engineer:** Nelson Ferreira

Sub-Surface Log

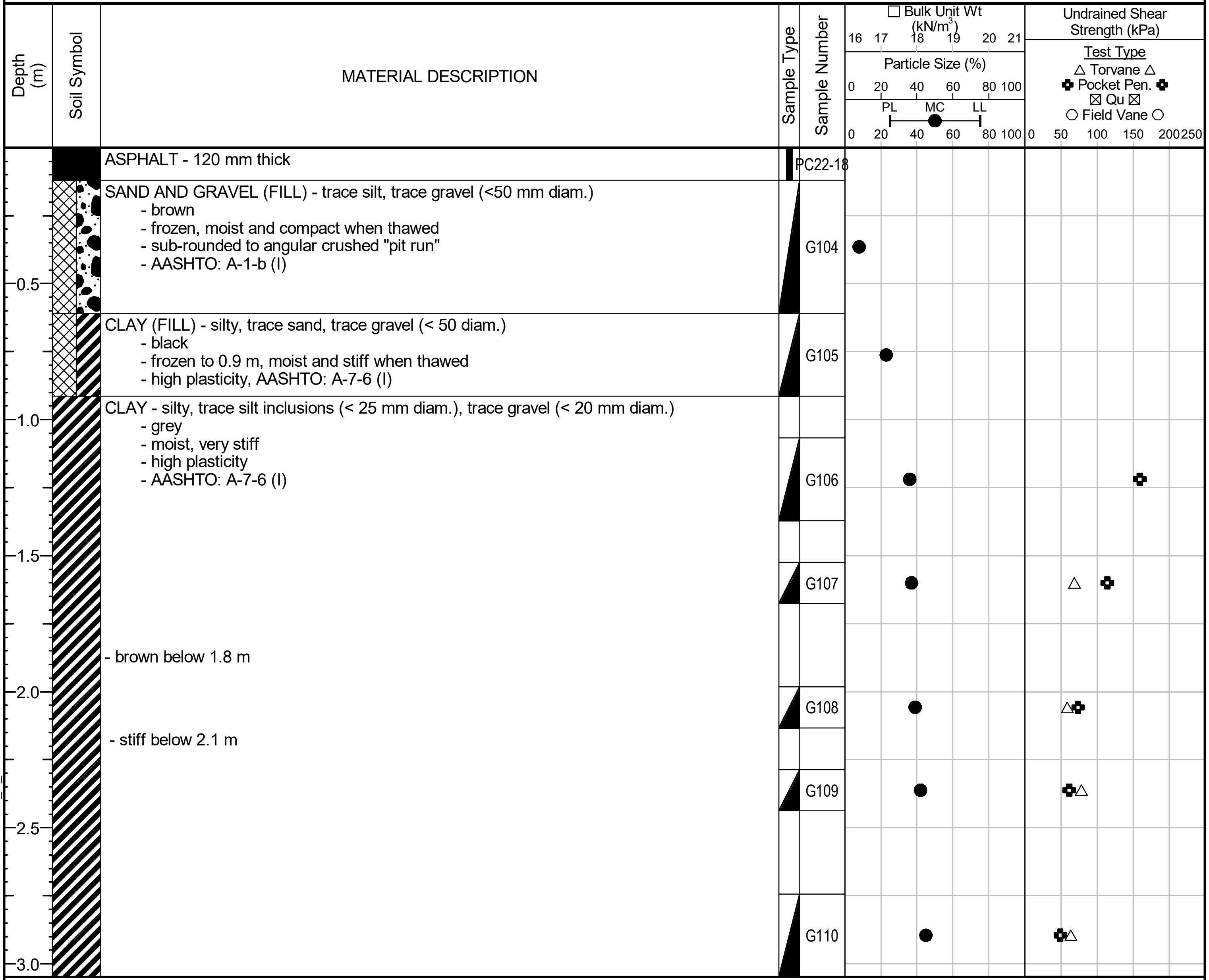
Test Hole TH22-19 (Springfield Rd)

1 of 1

Client: WSP Canada Group Ltd.
Project Number: 1000-043-22
Project Name: 2023 Local and Industrial Streets Renewal Package (23-RI-02)
Location: UTM N-5532787, E-641090
Contractor: Maple Leaf Drilling Ltd.
Ground Elevation: Top of Pavement
Method: 125mm Solid Stem Auger, B40 Mobile Truck Mount
Date Drilled: November 15, 2022

Sample Type: ◢ Grab (G) ▮ Shelby Tube (T) ☒ Split Spoon (SS) / SPT ☒ Split Barrel (SB) / LPT ▮ Core (C)

Particle Size Legend: ▨ Fines ▨ Clay ▥ Silt ▒ Sand ● Gravel ▨ Cobbles ■ Boulders



ASPHALT - 120 mm thick

SAND AND GRAVEL (FILL) - trace silt, trace gravel (<50 mm diam.)
- brown
- frozen, moist and compact when thawed
- sub-rounded to angular crushed "pit run"
- AASHTO: A-1-b (I)

CLAY (FILL) - silty, trace sand, trace gravel (< 50 diam.)
- black
- frozen to 0.9 m, moist and stiff when thawed
- high plasticity, AASHTO: A-7-6 (I)

CLAY - silty, trace silt inclusions (< 25 mm diam.), trace gravel (< 20 mm diam.)
- grey
- moist, very stiff
- high plasticity
- AASHTO: A-7-6 (I)

- brown below 1.8 m

- stiff below 2.1 m

END OF TEST HOLE AT 3.0 m IN CLAY.
1) Seepage or sloughing not observed.
2) Test hole dry and open to 3.0 m depth immediately after drilling.
3) Test hole backfilled with auger cuttings, bentonite chips and cold patch asphalt.
4) Test hole located in front of #1867 Springfield Rd, 0.5 m South of North edge of road.
5) The bulk sample was collected between 0.6 and 3.0 m depth.

Logged By: Jashandeep Singh Bhullar
Reviewed By: Angela Fidler-Kliewer
Project Engineer: Nelson Ferreira

2023 Local and Industrial Streets Renewal Project - 23-RI-02
Sub-Surface Investigation
Springfield Rd - Lagimodiere Blvd / Cox Blvd

Test Hole No.	Test Hole Location	Pavement Surface		Pavement Structure Material		Subgrade Description	Sample Depth (m)		Moisture Content (%)	Grain Size Analysis				Atterberg Limits		
		Type	Thickness (mm)	Type	Thickness (mm)		Top (m)	Bottom (m)		Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Plastic	Liquid	Plasticity Index
TH22-17	UTM: 14U 5532780 N, 640485 E Located in front of #1100 Springfield Rd, 1.4 m North of South edge of road.	Asphalt	95	Concrete	-	Sand And Gravel (Fill); AASHTO: A-1-b (I)	0.1	0.5	5							
						Clay (Fill); AASHTO: A-7-6 (I)	0.5	0.6	13							
						Clay (Fill); AASHTO: A-7-6 (I)	0.9	1.1	15							
						Clay; AASHTO: A-7-6 (I)	1.1	1.4	34							
						Silt; AASHTO: A-4 (I)	1.5	1.8	25							
						Clay; AASHTO: A-7-6 (I)	2.0	2.1	27							
						Clay; AASHTO: A-7-6 (I)	2.3	2.4	37							
						Clay; AASHTO: A-7-6 (I)	2.6	2.9	41							
TH22-18	UTM: 14U 5532787 N, 641090 E Located in front of #1100-1180 Springfield Rd, 1.1 m South of North edge of road.	Asphalt	105	Concrete	-	Sand And Gravel (Fill); AASHTO: A-1-b (I)	0.1	0.6	28							
						Clay (Fill); AASHTO: A-7-6 (I)	0.8	1.1	16							
						Clay; AASHTO: A-7-6 (57)	1.1	1.2	28	62	34	3	1	22	75	53
						Clay; AASHTO: A-7-6 (57)	1.4	1.5	28							
						Clay; AASHTO: A-7-6 (57)	1.7	1.8	28							
						Clay; AASHTO: A-7-6 (57)	2.0	2.1	29							
						Clay; AASHTO: A-7-6 (57)	2.3	2.5	35							
						Clay; AASHTO: A-7-6 (57)	2.7	3.0	41							
TH22-19	UTM: 14U 5532792 N, 641817 E Located in front of #1867 Springfield Rd, 0.5 m South of North edge of road.	Asphalt	120	Concrete	-	Sand And Gravel (Fill); AASHTO: A-1-b (I)	0.1	0.6	8							
						Clay (Fill); AASHTO: A-7-6 (I)	0.6	0.9	23							
						Clay; AASHTO: A-7-6 (I)	1.1	1.4	36							
						Clay; AASHTO: A-7-6 (I)	1.5	1.7	37							
						Clay; AASHTO: A-7-6 (I)	2.0	2.1	39							
						Clay; AASHTO: A-7-6 (I)	2.3	2.4	42							
						Clay; AASHTO: A-7-6 (I)	2.7	3.0	45							

(I) - AASHTO classification was interpreted based on visual classification.

TREK GEOTECHNICAL
www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

Moisture Content Report
ASTM D2216-10

Project No. 1000-043-22
Client WSP Canada Group LTD
Project 2023 Local and Industrial Streets Package (23-RI-02) - Springfield Rd.

Sample Date 25-Nov-22
Test Date 29-Nov-22
Technician TR

Test Hole	TH22-17	TH22-17	TH22-17	TH22-17	TH22-17	TH22-17
Depth (m)	0.1 - 0.5	0.5 - 0.6	0.9 - 1.1	1.1 - 1.4	1.5 - 1.8	2.0 - 2.1
Sample #	G96	G97	G98	G99	G100	G101
Tare ID	A16	W41	K29	D47	F110	H70
Mass of tare	8.7	8.6	8.5	8.9	8.3	8.8
Mass wet + tare	260.1	232.1	235.8	256.6	253.3	235.6
Mass dry + tare	247.3	206.3	205.8	194.1	203.8	188.0
Mass water	12.8	25.8	30.0	62.5	49.5	47.6
Mass dry soil	238.6	197.7	197.3	185.2	195.5	179.2
Moisture %	5.4%	13.1%	15.2%	33.7%	25.3%	26.6%

Test Hole	TH22-17	TH22-17	TH22-18	TH22-18	TH22-18	TH22-18
Depth (m)	2.3 - 2.4	2.6 - 2.9	0.1 - 0.6	0.8 - 1.1	1.1 - 1.2	1.4 - 1.5
Sample #	G102	G103	G111	G112	G113	G114
Tare ID	F35	Z01	Z40	E87	Z107	AC03
Mass of tare	8.6	8.7	8.5	8.8	7.0	6.8
Mass wet + tare	230.6	212.3	319.2	296.9	235.8	223.1
Mass dry + tare	170.4	152.9	250.9	257.3	185.7	176.0
Mass water	60.2	59.4	68.3	39.6	50.1	47.1
Mass dry soil	161.8	144.2	242.4	248.5	178.7	169.2
Moisture %	37.2%	41.2%	28.2%	15.9%	28.0%	27.8%

Test Hole	TH22-18	TH22-18	TH22-18	TH22-18	TH22-19	TH22-19
Depth (m)	1.7 - 1.8	2.0 - 2.1	2.3 - 2.5	2.7 - 3.0	0.1 - 0.6	0.6 - 0.9
Sample #	G115	G116	G117	G118	G104	G105
Tare ID	W111	F42	N75	F31	W22	W80
Mass of tare	8.6	8.6	8.9	8.7	8.6	8.9
Mass wet + tare	209.3	217.7	272.0	224.2	243.4	223.6
Mass dry + tare	165.6	170.9	203.3	161.2	225.8	184.1
Mass water	43.7	46.8	68.7	63.0	17.6	39.5
Mass dry soil	157.0	162.3	194.4	152.5	217.2	175.2
Moisture %	27.8%	28.8%	35.3%	41.3%	8.1%	22.5%

www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

Moisture Content Report
ASTM D2216-10

Project No. 1000-043-22
Client WSP Canada Group LTD
Project 2023 Local and Industrial Streets Package (23-RI-02) - Springfield Rd.

Sample Date 25-Nov-22
Test Date 29-Nov-22
Technician TR

Test Hole	TH22-19	TH22-19	TH22-19	TH22-19	TH22-19	
Depth (m)	1.1 - 1.4	1.5 - 1.7	2.0 - 2.1	2.3 - 2.4	2.7 - 3.0	
Sample #	G106	G107	G108	G109	G110	
Tare ID	F124	AC37	N01	W102	N35	
Mass of tare	8.7	6.9	8.6	8.7	8.7	
Mass wet + tare	224.4	239.5	258.1	233.5	225.4	
Mass dry + tare	166.9	176.8	188.3	167.5	158.0	
Mass water	57.5	62.7	69.8	66.0	67.4	
Mass dry soil	158.2	169.9	179.7	158.8	149.3	
Moisture %	36.3%	36.9%	38.8%	41.6%	45.1%	

TREK GEOTECHNICAL
www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

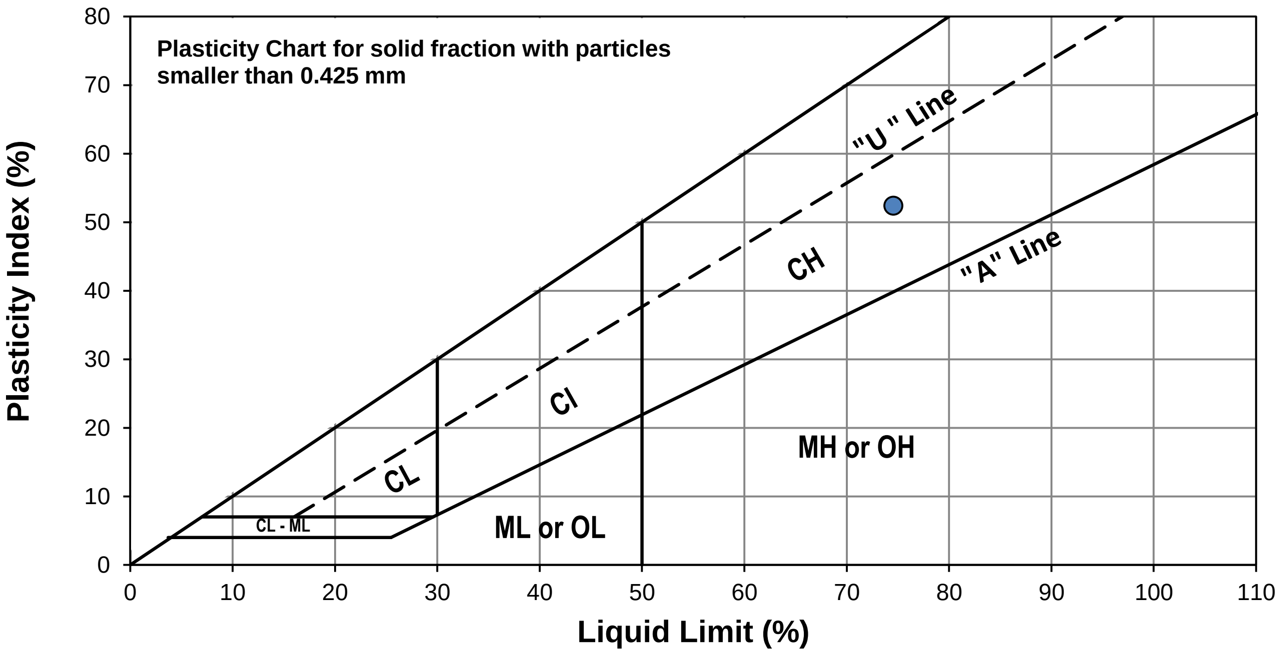
Atterberg Limits
ASTM D4318-10e1

Project No.	1000-043-22
Client	WSP Canada Group Ltd.
Project	2023 Local and Industrial Streets Renewal Package (23-RI-02)
Test Hole	TH22-18
Sample #	G113
Depth (m)	1.1 - 1.2
Sample Date	25-Nov-22
Test Date	07-Dec-22
Technician	DS

Liquid Limit	75
Plastic Limit	22
Plasticity Index	52

Liquid Limit

Trial #	**1**	**2**	**3**		
Number of Blows (N)	18	21	28		
Mass Tare (g)	14.080	14.222	14.226		
Mass Wet Soil + Tare (g)	22.774	22.688	23.191		
Mass Dry Soil + Tare (g)	18.959	19.022	19.397		
Mass Water (g)	3.815	3.666	3.794		
Mass Dry Soil (g)	4.879	4.800	5.171		
Moisture Content (%)	78.192	76.375	73.371		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Tare (g)	14.179	14.016			
Mass Wet Soil + Tare (g)	23.325	22.488			
Mass Dry Soil + Tare (g)	21.683	20.932			
Mass Water (g)	1.642	1.556			
Mass Dry Soil (g)	7.504	6.916			
Moisture Content (%)	21.882	22.499			

Note: Additional information recorded/measured for this test is available upon request.

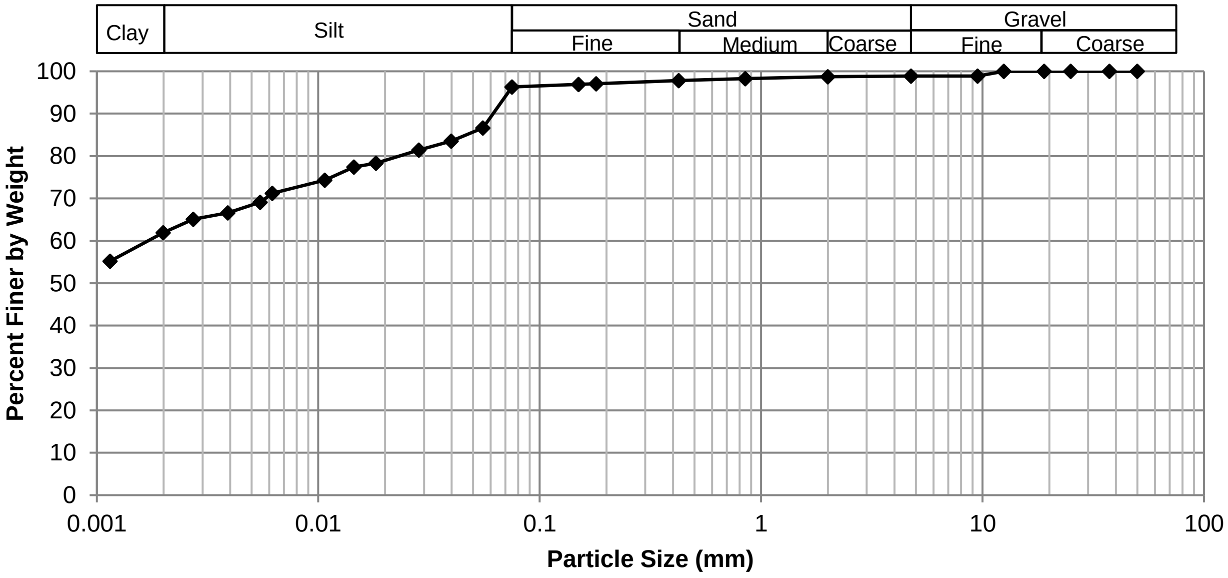
www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

Grain Size Analysis (Hydrometer Method)
AASHTO T 88

Project No.	1000-043-22
Client	WSP Canada Group Ltd.
Project	2023 Local Street and Industrial Package (23-RI-02) Springfield Rd
Test Hole	TH22-18
Sample #	G113
Depth (m)	1.1 - 1.2
Sample Date	25-Nov-22
Test Date	6-Dec-22
Technician	DS

Gravel	1.1%
Sand	2.5%
Silt	34.4%
Clay	61.9%

Particle Size Distribution Curve



Gravel		Sand		Silt and Clay	
Particle Size (mm)	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**
50.0	100.00	4.75	98.85	0.0750	96.31
37.5	100.00	2.00	98.71	0.0555	86.65
25.0	100.00	0.850	98.26	0.0398	83.56
19.0	100.00	0.425	97.81	0.0284	81.40
12.5	100.00	0.180	97.08	0.0182	78.32
9.50	98.85	0.150	96.92	0.0145	77.39
4.75	98.85	0.075	96.31	0.0107	74.31
				0.0062	71.22
				0.0055	69.10
				0.0039	66.63
				0.0027	65.09
				0.0020	61.92
				0.0012	55.23

TREK GEOTECHNICAL
www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

Standard Proctor Compaction Test

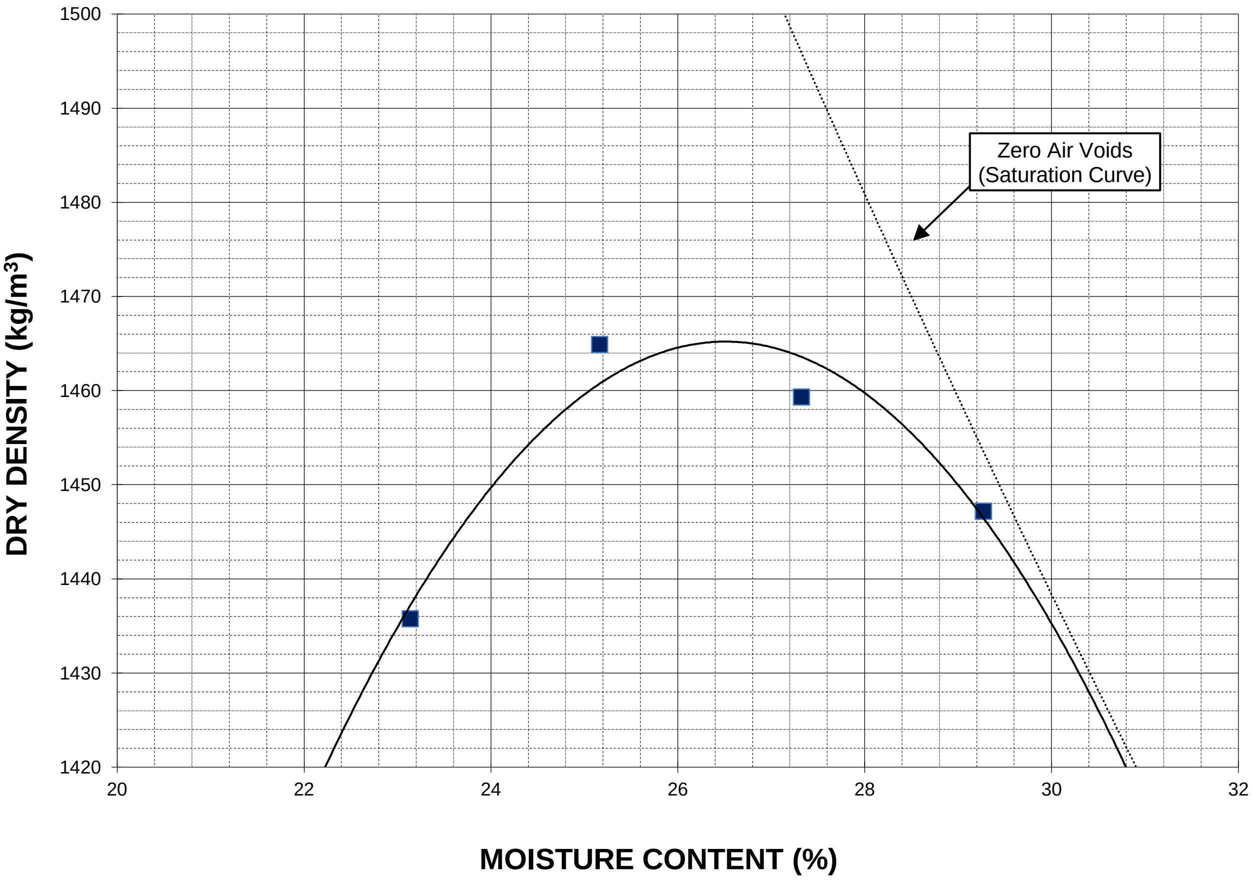
ASTM D698-12 (2021)

CERTIFIED BY CCIL Canadian Council of Independent Laboratories For specific tests as listed on www.ccil.com

Project No.	1000-043-22
Client	WSP Canada Group LTD
Project	2023 Local and Industrial Streets Package (23-RI-02)
Sample #	TH22-18 & TH22-19 (combined)
Source	Springfield Rd.
Material	Clay
Sample Date	20-Nov-22
Test Date	02-Dec-22
Technician	TG

Maximum Dry Density (kg/m3)	1465
Optimum Moisture (%)	26.5

Trial Number	1	2	3	4	
Wet Density (kg/m^3)	1768	1834	1858	1871	
Dry Density (kg/m^3)	1436	1465	1459	1447	
Moisture Content (%)	23.1	25.2	27.3	29.3	



Note: Additional information recorded/measured for this test is available upon request.

TREK GEOTECHNICAL
www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

California Bearing Ratio Test Data Sheet

ASTM D1883-16

Project No.	1000-043-22	**Source**	Springfield Rd.
Client	WSP Canada Group Ltd.	**Material**	Clay
Project	2023 Local Streets Renewal (23-RI-02)	**Sample Date**	2022-11-25
Sample #	TH22-18 & TH22-19 (combined)	**Test Date**	2022-12-05
		Technician	TG

Proctor Results (ASTM D698)

Maximum Dry Density	1465	kg/m3
Optimum Moisture Content	26.5	%
Material Retained on 19 mm Sieve	0.0	%

CBR Sample Compaction

Dry Density	1392	kg/m3
Initial Moisture Conten	28.0	%
Relative Density	95.0	% SPMDD

Soaking Results

Surcharge	4.54	kg
Swell	2.3	%
Moisture Content in top 25 mm	39.8	%
Immersion Period	96	h

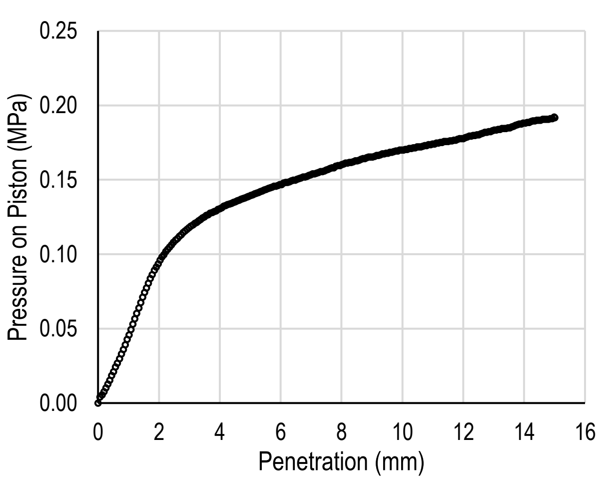
CBR Results

CBR at 2.54 mm	1.6	%
CBR at 5.08 mm	1.4	%
Zero Correction	0	mm

Test Data

Penetration (mm)	Measured Pressure (MPa)	Corrected Pressure (MPa)
0.64	0.03	0.03
1.27	0.06	0.06
1.91	0.09	0.09
2.54	0.11	0.11
3.18	0.12	0.12
3.81	0.13	0.13
4.45	0.13	0.13
5.08	0.14	0.14
7.62	0.16	0.16
10.16	0.17	0.17
12.70	0.18	0.18

Load/Penetration Curve



Comments:

1712 St. James Street
Winnipeg, Manitoba R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435
www.trekgeotechnical.ca

Project 1000-043-22
Location Springfield (23-RI-02)
Hole No. TH22-17 Sample No. PC 17
Depth 95mm
Technician TG Date Nov 16/22

Photo 1: Pavement Core Sample at TH22-17

1712 St. James Street
Winnipeg, Manitoba R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435
www.trekgeotechnical.ca

Project 1000-043-22
Location Springfield (23-RI-02)
Hole No. TH22-18 Sample No. PC18
Depth 105mm
Technician TG Date Nov 16/22

Photo 2: Pavement Core Sample at TH22-18

Project 1000-043-22

Location Springfield (23-RI-02)

Hole No. TH22-19 Sample No. PC 19

Depth 120 mm

Technician TG Date Nov 16/22

Photo 3: Pavement Core Sample at TH22-19

Appendix D

Summary Table and Pavement Core Photos – Dugald Rd.

2023 Local and Industrial Streets Renewal Package - 23-RI-02

Dugald Rd - Panet Rd / Dawson Rd N

Pavement Core No.	Pavement Core Location	Pavement Surface		Pavement Structure Material		
		Type	Thickness (mm)	Type	Thickness (mm)	Corrected Compressive Strength (Mpa)
PC22-09	UTM: 14U 5527708 N, 637445 E; Located in front of #811 Dugald Rd, 1.7 m South of North curb of the road.	Asphalt	-	Concrete	200	-
PC22-10	UTM: 14U 5527715 N, 637561 E; Located in front of #853 Dugald Rd, 1.5 m North of South curb of the road.	Asphalt	-	Concrete	205	62.49
PC22-11	UTM: 14U 5527715 N, 637719 E; Located in front of #901-807 Dugald Rd, 1.5 m North of South curb of the road.	Asphalt	-	Concrete	200	-
PC22-12	UTM: 14U 5527725 N, 637940 E; Located north of #110 Panet Rd, 1.4 m South of North curb of the road.	Asphalt	-	Concrete	180	-

1712 St. James Street
Winnipeg, Manitoba R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435
www.trekgeotechnical.ca

Project 1000-043-22
Location Dugald rd. (23-RI-02)
Hole No. PC-09 Sample No. PC-09
Depth 190mm
Technician TG/SSA Date Nov 8/22

Photo 1: Pavement Core Sample PC-09

1712 St. James Street
Winnipeg, Manitoba R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435
www.trekgeotechnical.ca

Project 1000-043-22
Location Dugald rd. (23-RI-02)
Hole No. PC-10 Sample No. PC-10
Depth 200mm
Technician TG/SSA Date Nov 8/22

Photo 2: Pavement Core Sample PC-10

1712 St. James Street
Winnipeg, Manitoba R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435
www.trekgeotechnical.ca

Project 1000-043-22
Location Dugald. rd (23-R1-02)
Hole No. PC-11 Sample No. PC-11
Depth 200mm
Technician TG/JSB Date Nov 10/22

Photo 1: Pavement Core Sample PC-11

1712 St. James Street
Winnipeg, Manitoba R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435
www.trekgeotechnical.ca

Project 1000-043-22
Location Dugald rd. (23-R1-02)
Hole No. PC-12 Sample No. PC-12
Depth 180mm
Technician TG/JSB Date Nov 10/22

Photo 2: Pavement Core Sample PC-12

TREK GEOTECHNICAL
www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

Concrete Core Compressive Strength Report

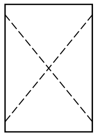
CSA A23.2-14C

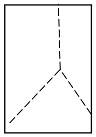
Project No. 1000-043-22
Date December 14, 2022
Project 2023 Local Streets Package - 23-R1-02
Technician KM
Client WSP Group Canada Inc.

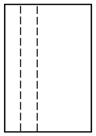
Core Location	Core ID	Date Received	Date of Break	Age at Break	Diam. (mm)	Length (mm)	Moisture Conditioning	Compressive Strength (MPa)		Break Type	Correction Factors*				
								Uncorrected f_{conc}	Corrected* f_c		$F_{l/d}$	F_{dia}	F_{mc}	F_D	F_{reinf}
Dugald Road	PC-10	2022-11-08	2022-12-14	-	145	194	Soaked 48 h	53.30	62.49	1	0.9588	0.9802	1.0900	1.0600	1.0798

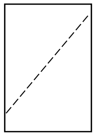
Comments

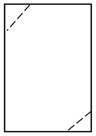
*Correction factors $F_{l/d}$, F_{dia}, F_{mc}, and F_D calculated as per ACI 214.4R-03, and correction factor F_{reinf} calculated as per Khoury et al. (2014): $f_c = f_{conc}F_{l/d}F_{dia}F_{mc}F_DF_{reinf}$

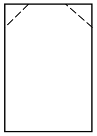

Type 1


Type 2


Type 3


Type 4


Type 5


Type 6

Reviewed by (print): Angela Fidler-Kliewer, C.Tech.

Signature: Angela Fidler-Kliewer

Table 1 Factors involved in interpretation of core results by different codes.

List	Code/standard	Edition	Factors Considered					
			Aspect ratio	Diameter	Reinforcing	Moisture	Damage	Direction
1	Egyptian Code/Standard Specification	2008	✓		✓			✓
2	British Code/Standard Specification	2003	✓		✓			✓
3	American Concrete Institute ACI	1998	✓					
		2012	✓	✓		✓	✓	
4	European Standard Specification	1998	✓	✓	✓		✓	
		2009	✓		✓			
5	Japanese Standard	1998	✓					
6	Concrete Society	1987	✓		✓		✓	✓

In addition, for core specimen containing two bars no further apart than the diameter of the larger bar, only the bar corresponding to the higher value of ($\Phi_r * d$) is considered. If the bars are further apart, their combined effect should be assessed by replacing the term ($\Phi_r * d$) by the term ($\sum \Phi_r * d$).

It should be pointed out that above equations used to interpret the core concrete strength to the in-situ concrete cube strength have been developed based on a set of assumptions and through many converting process. It is also of interest to note that the damage effect is considered in the development of the formulas in indirect way. The subject derivation and detailed formulas may be seen elsewhere [14].

3.2. American Concrete Institute (ACI)

3.2.1. Former ACI Code (2002) & Current ASTM (2009)

The methodology of core interpretation given in the former ACI code was remained without changes for decades and up to Year (2003). The in-place strength of concrete cylinder at the location from which a core test specimen was extracted can be computed using the equation:

$$f_{cy} = F_{l/d} \cdot f_{core} \tag{4}$$

where f_{cy} is the equivalent in-place concrete cylinder strength, f_{core} is concrete core strength, and $F_{l/d}$ is the strength correction factor for aspect ratio.

The former ACI code does not include any equation to calculate the correction factor ($F_{l/d}$); however, the code gives different values for this term that is associated with different aspect ratios (l/d) as given in Table 2. It should also be noted that the approach of current ASTM is similar to that mentioned above. The only considered variable is the aspect ratio (l/d). It should be noted that identical approach to that mentioned above is still effective in ASTM C42/C42M-03 [10].

3.2.2. Current ACI Code (2012) [15]

Starting from Year 2003, significant changes have been made to the relevant ACI Code provisions regarding the interpretation of core strength test results. New factors have been considered. These include core diameter, moisture content of core sample, core damage associated with drilling, in addition to the effect of aspect ratio that was previously considered in the former ACI edition (1998). According to the ACI 214.4R-03, the in-place concrete strength can be computed using the equation:

← Eq. 12

$$f_c = F_{l/d} \cdot F_{dia} \cdot F_{mc} \cdot F_D \cdot f_{core} \cdot F_{point} \tag{5}$$

or Eq. 15

where f_c is the equivalent in-place concrete cylinder strength, f_{core} is concrete core strength, $F_{l/d}$ is strength correction factor for aspect ratio, F_{dia} is strength correction factors for diameter, F_{mc} is strength correction factor for moisture condition of core sample, and F_D is the strength correction factor that accounts for effect of damage sustained during core drilling including micro-cracking and undulations at the drilled surface and cutting through coarse-aggregate particles that may subsequently pop out during testing.

The ACI committee considered the correction factors presented in Table 3 for converting core strengths into equivalent in-place strengths based on the work reported by Bartlett and MacGregor [6]. It should be noted that the magnitude of

Table 2 Mean values for factor $F_{l/d}$ according to ACI Code (1998) and ASTM.

	Specimen length-to-diameter ratio, l/d			
	1.00	1.25	1.50	1.75
$F_{l/d}$	0.87	0.93	0.96	0.98

Table 3 Strength correction factors according to ACI 214.4R-03.

List	Factors	Mean values
(1)[b]	$F_{l/d}$:l/d ratio	
	As-received	$1-\{0.130-\alpha f_{core}\}(2-\frac{l}{d})^2$
	Soaked 48 h	$1-\{0.117-\alpha f_{core}\}(2-\frac{l}{d})^2$
	Air dried[a]	$1-\{0.144-\alpha f_{core}\}(2-\frac{l}{d})^2$
(2)	F_{dia}: core diameter	
	50 mm	1.06
	100 mm	1.00
	150 mm	0.98
(3)	F_{mc}: core moisture content	
	As-received	1.00
	Soaked 48 h	1.09
	Air dried[a]	0.96
(4)	F_D: damage due to drilling	1.06

[a] Standard treatment specified in ASTM C 42/C 42M.

[b] Constant α equals $4.3(10^{-4})$ 1/MPa for f_{core} in MPa.

Table 6 List of comparisons between tested cores to determine.

	A18	A17	A16	A15	A14	A13	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1
A1	♦●	●	♦●	■●	■●		●				●			▲	▲	■	▲	
A2																		
A3						■●				■●								
A4																		
A5																		
A6								■▲●	■▲●			■▲						
A7								■▲●	■▲●									
A8		●	♦	●	●													
A9																		
A10								■▲●										
A11																		
A12		●		●	●													
A13																		
A14		●		●														
A15		●																
A16	●♦																	
A17	♦																	
A18																		

● Diameter of steel bar.
▲ Distance of steel bar from nearly end of core.
■ Number of steel bars and spacing between bars.
♦ Distance of steel bar from vertical axis of specimen.

This brief review indicated that the various proposed relationships for correction factors are all nonlinear. It should be noted that the equations given by the Egyptian Code takes into account most variables that may affect the interpretation of the results; however, the code ignores the deterioration of steel–concrete bond that may occur and also the position of the reinforcement from vertical axis of core specimens.

Weighted nonlinear regression analysis has been performed to determine the factor (F_{reinf}) with the use of the software "SAS" package and "Data Fit." This shows that the correction factor for reinforcement (F_{reinf}) is given by the following expression:

- For cores containing a single bar:

single bar

$$F_{\text{reinf}} = \left[1 + 1.5\frac{[\Phi_r \times r + \Phi_r \times (S/10)]}{\Phi_c * L}\right] \times \frac{1.13}{f_{\text{core}}^{0.015}} \quad (12)$$

- For core specimen containing two bars no further apart than the diameter of the larger bar, only the bar corresponding to the higher value of ($\Phi_r * d$) is considered. If the bars are further apart, their combined effect is assessed by replacing the term ($\Phi_r * r$) by ($\sum \Phi_r * r$ as follows:

multiple bars

$$F_{\text{reinf}} = \left[1 + 1.5\frac{\sum[\Phi_r \times r + \Phi_r \times (S/10)]}{\Phi_c * L}\right] \times \frac{1.13}{f_{\text{core}}^{0.015}} \quad (13)$$

where F_{reinf} is the correction factor for reinforcement, Φ_r is the diameter of the reinforcement, Φ_c is the diameter of the concrete specimen, r is the distance of axis of bar from nearer end of specimen, S is the distance of axis of bar from axis of core specimen, L is the length of the specimen after end preparation by grinding or capping, and f_{core} is the concrete core strength (kg/cm^2).

6.1.6. *Effect of moisture condition of core*

Results of about 100 cores indicate that the strength of cores left to dry in air for 7 days is on average 13% greater than that of cores soaked at least 40 h before testing. The strength of cores with negligible moisture gradient and tested after cutting is found to be 7–9% larger than that of soaked cores as shown in Fig. 20. The authors strongly recommend to use a correction factor accounting for moisture condition (F_m) equals to 1.09 and 0.96, respectively, for cores tested after 48 h soaked in water and for those tested after 7 days dry in air.

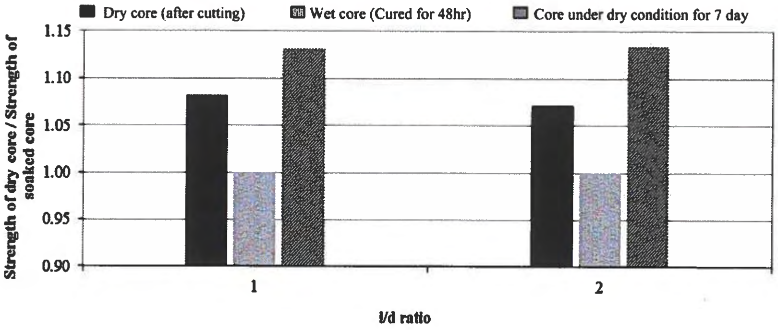


Figure 20 Effect of core moisture condition on core strength for different aspect ratios (l/d).

Appendix E

Summary Table and Pavement Core Photos – Mazenrod Rd.

2023 Local and Industrial Streets Renewal Package - 23-RI-02

Mazenod Rd SB nad NB - Dugald Rd / De Baets St

Pavement Core No.	Pavement Core Location	Pavement Surface		Pavement Structure Material		
		Type	Thickness (mm)	Type	Thickness (mm)	Corrected Compressive Strength (Mpa)
PC22-13	UTM: 14U 5527658 N, 640101 E; Located in front of Unit - 7 #16 Mazenod Rd, 1.6 m West of the median curb in Southboud median lane of the road.	Asphalt	45	Concrete	200	-
PC22-14	UTM: 14U 5527675 N, 640110 E; Located in front of Unit - 3 #16 Mazenod Rd, 1.7 m East of the median curb in Northboud median lane of the road.	Asphalt	45	Concrete	205	55.22

Photo 1: Pavement Core Sample PC-13

Photo 2: Pavement Core Sample PC-14

TREK GEOTECHNICAL
www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

Concrete Core Compressive Strength Report

CSA A23.2-14C

Project No. 1000-043-22

Project 2023 Local Streets Package - 23-R1-02

Client WSP Group Canada Inc.

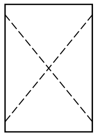
Date December 14, 2022

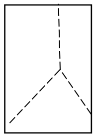
Technician KM

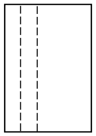
Core Location	Core ID	Date Received	Date of Break	Age at Break	Diam. (mm)	Length (mm)	Moisture Conditioning	Compressive Strength (MPa)		Break Type	Correction Factors*				
								Uncorrected f_{conc}	Corrected* f_c		$F_{l/d}$	F_{dia}	F_{mc}	F_D	F_{reinf}
Mazenod Road	PC-14	2022-11-08	2022-12-14	-	145	191	Soaked 48 h	46.73	55.22	1	0.9548	0.9802	1.0900	1.0600	1.0929

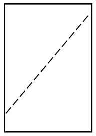
Comments

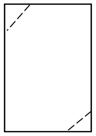
*Correction factors $F_{l/d}$, F_{dia}, F_{mc}, and F_D calculated as per ACI 214.4R-03, and correction factor F_{reinf} calculated as per Khoury et al. (2014): $f_c = f_{conc}F_{l/d}F_{dia}F_{mc}F_DF_{reinf}$

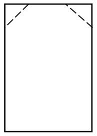

Type 1


Type 2


Type 3


Type 4


Type 5


Type 6

Reviewed by (print): Angela Fidler-Kliewer, C.Tech.

Signature: Angela Fidler-Kliewer

Table 1 Factors involved in interpretation of core results by different codes.

List	Code/standard	Edition	Factors Considered					
			Aspect ratio	Diameter	Reinforcing	Moisture	Damage	Direction
1	Egyptian Code/Standard Specification	2008	√		√			√
2	British Code/Standard Specification	2003	√		√			√
3	American Concrete Institute ACI	1998	√					
		2012	√	√		√	√	
4	European Standard Specification	1998	√	√	√		√	
		2009	√		√			
5	Japanese Standard	1998	√					
6	Concrete Society	1987	√		√		√	√

In addition, for core specimen containing two bars no further apart than the diameter of the larger bar, only the bar corresponding to the higher value of ($\Phi_r * d$) is considered. If the bars are further apart, their combined effect should be assessed by replacing the term ($\Phi_r * d$) by the term ($\sum \Phi_r * d$).

It should be pointed out that above equations used to interpret the core concrete strength to the in-situ concrete cube strength have been developed based on a set of assumptions and through many converting process. It is also of interest to note that the damage effect is considered in the development of the formulas in indirect way. The subject derivation and detailed formulas may be seen elsewhere [14].

3.2. American Concrete Institute (ACI)

3.2.1. Former ACI Code (2002) & Current ASTM (2009)

The methodology of core interpretation given in the former ACI code was remained without changes for decades and up to Year (2003). The in-place strength of concrete cylinder at the location from which a core test specimen was extracted can be computed using the equation:

$$f_{cy} = F_{l/d} \cdot f_{core} \quad (4)$$

where f_{cy} is the equivalent in-place concrete cylinder strength, f_{core} is concrete core strength, and $F_{l/d}$ is the strength correction factor for aspect ratio.

The former ACI code does not include any equation to calculate the correction factor ($F_{l/d}$); however, the code gives different values for this term that is associated with different aspect ratios (l/d) as given in Table 2. It should also be noted that the approach of current ASTM is similar to that mentioned above. The only considered variable is the aspect ratio (l/d). It should be noted that identical approach to that mentioned above is still effective in ASTM C42/C42M-03 [10].

3.2.2. Current ACI Code (2012) [15]

Starting from Year 2003, significant changes have been made to the relevant ACI Code provisions regarding the interpretation of core strength test results. New factors have been considered. These include core diameter, moisture content of core sample, core damage associated with drilling, in addition to the effect of aspect ratio that was previously considered in the former ACI edition (1998). According to the ACI 214.4R-03, the in-place concrete strength can be computed using the equation:

← eq. 12

$$f_c = F_{l/d} \cdot F_{dia} \cdot F_{mc} \cdot F_D \cdot f_{core} \cdot F_{romt} \quad \text{or eq. 15} \quad (5)$$

where f_c is the equivalent in-place concrete cylinder strength, f_{core} is concrete core strength, $F_{l/d}$ is strength correction factor for aspect ratio, F_{dia} is strength correction factors for diameter, F_{mc} is strength correction factor for moisture condition of core sample, and F_D is the strength correction factor that accounts for effect of damage sustained during core drilling including micro-cracking and undulations at the drilled surface and cutting through coarse-aggregate particles that may subsequently pop out during testing.

The ACI committee considered the correction factors presented in Table 3 for converting core strengths into equivalent in-place strengths based on the work reported by Bartlett and MacGregor [6]. It should be noted that the magnitude of

Table 2 Mean values for factor $F_{l/d}$ according to ACI Code (1998) and ASTM.

	Specimen length-to-diameter ratio, l/d			
	1.00	1.25	1.50	1.75
$F_{l/d}$	0.87	0.93	0.96	0.98

Table 3 Strength correction factors according to ACI 214.4R-03.

List	Factors	Mean values
(1)[b]	$F_{l/d}$:l/d ratio	
	As-received	$1 - \{0.130 - \alpha f_{core}\}(2 - \frac{l}{d})^2$
	Soaked 48 h	$1 - \{0.117 - \alpha f_{core}\}(2 - \frac{l}{d})^2$
	Air dried[a]	$1 - \{0.144 - \alpha f_{core}\}(2 - \frac{l}{d})^2$
(2)	F_{dia}: core diameter	
	50 mm	1.06
	100 mm	1.00
	150 mm	0.98
(3)	F_{mc}: core moisture content	
	As-received	1.00
	Soaked 48 h	1.09
	Air dried[a]	0.96
(4)	F_D: damage due to drilling	1.06

[a] Standard treatment specified in ASTM C 42/C 42M.
[b] Constant α equals $4.3(10^{-4})$ 1/MPa for f_{core} in MPa.

Table 6 List of comparisons between tested cores to determine.

	A18	A17	A16	A15	A14	A13	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1
A1	♦●	●	♦●	■●	■●		●				●			▲	▲	■	▲	
A2																		
A3						■●				■●								
A4																		
A5																		
A6								■▲●	■▲●			■▲						
A7								■▲●	■▲●									
A8		●	♦	●	●													
A9																		
A10								■▲●										
A11																		
A12		●		●	●													
A13																		
A14		●		●														
A15		●																
A16	●♦																	
A17	♦																	
A18																		

● Diameter of steel bar.
▲ Distance of steel bar from nearly end of core.
■ Number of steel bars and spacing between bars.
♦ Distance of steel bar from vertical axis of specimen.

This brief review indicated that the various proposed relationships for correction factors are all nonlinear. It should be noted that the equations given by the Egyptian Code takes into account most variables that may affect the interpretation of the results; however, the code ignores the deterioration of steel–concrete bond that may occur and also the position of the reinforcement from vertical axis of core specimens.

Weighted nonlinear regression analysis has been performed to determine the factor (F_{reinf}) with the use of the software "SAS" package and "Data Fit." This shows that the correction factor for reinforcement (F_{reinf}) is given by the following expression:

single bar

- For cores containing a single bar:

$$F_{\text{reinf}} = \left[1 + 1.5\frac{[\Phi_r \times r + \Phi_r \times (S/10)]}{\Phi_c * L}\right] \times \frac{1.13}{f_{\text{core}}^{0.015}} \quad (12)$$

- For core specimen containing two bars no further apart than the diameter of the larger bar, only the bar corresponding to the higher value of ($\Phi_r * d$) is considered. If the bars are further apart, their combined effect is assessed by replacing the term ($\Phi_r * r$) by ($\sum \Phi_r * r$ as follows:

multiple bars

$$F_{\text{reinf}} = \left[1 + 1.5\frac{\sum[\Phi_r \times r + \Phi_r \times (S/10)]}{\Phi_c * L}\right] \times \frac{1.13}{f_{\text{core}}^{0.015}} \quad (13)$$

where F_{reinf} is the correction factor for reinforcement, Φ_r is the diameter of the reinforcement, Φ_c is the diameter of the concrete specimen, r is the distance of axis of bar from nearer end of specimen, S is the distance of axis of bar from axis of core specimen, L is the length of the specimen after end preparation by grinding or capping, and f_{core} is the concrete core strength (kg/cm^2).

6.1.6. *Effect of moisture condition of core*

Results of about 100 cores indicate that the strength of cores left to dry in air for 7 days is on average 13% greater than that of cores soaked at least 40 h before testing. The strength of cores with negligible moisture gradient and tested after cutting is found to be 7–9% larger than that of soaked cores as shown in Fig. 20. The authors strongly recommend to use a correction factor accounting for moisture condition (F_m) equals to 1.09 and 0.96, respectively, for cores tested after 48 h soaked in water and for those tested after 7 days dry in air.

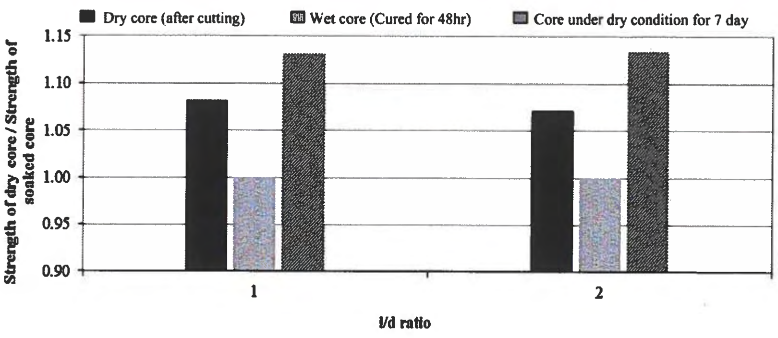


Figure 20 Effect of core moisture condition on core strength for different aspect ratios (l/d).

Appendix F

Summary Table and Pavement Core Photos – Beghin Ave

2023 Local and Industrial Streets Renewal Package - 23-RI-02

Beghin Ave - De Baets St / Paquin Rd

Pavement Core No.	Pavement Core Location	Pavement Surface		Pavement Structure Material		
		Type	Thickness (mm)	Type	Thickness (mm)	Corrected Compressive Strength (Mpa)
PC22-15	UTM: 14U 5527224 N, 640429 E; Located in front of #150 Beghin Ave, 1.2 m West of East curb of the road.	Asphalt	60	Concrete	190	63.29
PC22-16	UTM: 14U 5527440 N, 640505 E; Located in front of #70 Beghin Ave, 1.9 m East of West curb of the road.	Asphalt	-	Concrete	210	55.91

Project 1000-043-22
Location Beghin Ave (23-RI-02)
Hole No. PC-15 Sample No. PC-15
Depth 245mm
Technician KM/JSR Date Nov 8/22

Photo 1: Pavement Core Sample PC-15

Project 1000-043-22
Location Beghin Ave (23-RI-02)
Hole No. PC-16 Sample No. PC-16
Depth 210 mm
Technician KM/JSB Date Nov 8/22

Photo 2: Pavement Core Sample PC-16

www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

Concrete Core Compressive Strength Report

CSA A23.2-14C

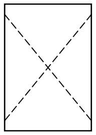
Project No. 1000-043-22
Project 2023 Local Streets Package - 23-R1-02
Client WSP Group Canada Inc.

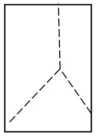
Date December 14, 2022
Technician KM

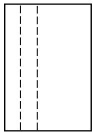
Core Location	Core ID	Date Received	Date of Break	Age at Break	Diam. (mm)	Length (mm)	Moisture Conditioning	Compressive Strength (MPa)		Break Type	Correction Factors*				
								Uncorrected f_{conc}	Corrected* f_c		$F_{l/d}$	F_{dia}	F_{mc}	F_D	F_{reinf}
Beghin Avenue	PC-15	2022-11-08	2022-12-14	-	145	174	Soaked 48 h	59.36	63.29	1	0.9415	0.9802	1.0900	1.0600	1.0000
Beghin Avenue	PC-16	2022-11-08	2022-12-14	-	145	188	Soaked 48 h	51.80	55.91	1	0.9531	0.9802	1.0900	1.0600	1.0000

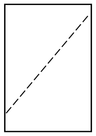
Comments

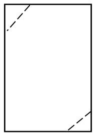
*Correction factors $F_{l/d}$, F_{dia}, F_{mc}, and F_D calculated as per ACI 214.4R-03, and correction factor F_{reinf} calculated as per Khoury et al. (2014): $f_c = f_{conc}F_{l/d}F_{dia}F_{mc}F_DF_{reinf}$

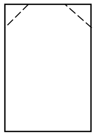

Type 1


Type 2


Type 3


Type 4


Type 5


Type 6

Reviewed by (print): Angela Fidler-Kliewer, C.Tech.

Signature: Angela Fidler-Kliewer

Table 1 Factors involved in interpretation of core results by different codes.

List	Code/standard	Edition	Factors Considered					
			Aspect ratio	Diameter	Reinforcing	Moisture	Damage	Direction
1	Egyptian Code/Standard Specification	2008	√		√			√
2	British Code/Standard Specification	2003	√		√			√
3	American Concrete Institute ACI	1998	√					
		2012	√	√		√	√	
4	European Standard Specification	1998	√	√	√		√	
		2009	√		√			
5	Japanese Standard	1998	√					
6	Concrete Society	1987	√		√		√	√

In addition, for core specimen containing two bars no further apart than the diameter of the larger bar, only the bar corresponding to the higher value of ($\Phi_r * d$) is considered. If the bars are further apart, their combined effect should be assessed by replacing the term ($\Phi_r * d$) by the term ($\sum \Phi_r * d$).

It should be pointed out that above equations used to interpret the core concrete strength to the in-situ concrete cube strength have been developed based on a set of assumptions and through many converting process. It is also of interest to note that the damage effect is considered in the development of the formulas in indirect way. The subject derivation and detailed formulas may be seen elsewhere [14].

3.2. American Concrete Institute (ACI)

3.2.1. Former ACI Code (2002) & Current ASTM (2009)

The methodology of core interpretation given in the former ACI code was remained without changes for decades and up to Year (2003). The in-place strength of concrete cylinder at the location from which a core test specimen was extracted can be computed using the equation:

$$f_{cy} = F_{l/d} \cdot f_{core} \qquad (4)$$

where f_{cy} is the equivalent in-place concrete cylinder strength, f_{core} is concrete core strength, and $F_{l/d}$ is the strength correction factor for aspect ratio.

The former ACI code does not include any equation to calculate the correction factor ($F_{l/d}$); however, the code gives different values for this term that is associated with different aspect ratios (l/d) as given in Table 2. It should also be noted that the approach of current ASTM is similar to that mentioned above. The only considered variable is the aspect ratio (l/d). It should be noted that identical approach to that mentioned above is still effective in ASTM C42/C42M-03 [10].

3.2.2. Current ACI Code (2012) [15]

Starting from Year 2003, significant changes have been made to the relevant ACI Code provisions regarding the interpretation of core strength test results. New factors have been considered. These include core diameter, moisture content of core sample, core damage associated with drilling, in addition to the effect of aspect ratio that was previously considered in the former ACI edition (1998). According to the ACI 214.4R-03, the in-place concrete strength can be computed using the equation:

eq. 12

$$f_c = F_{l/d} \cdot F_{dia} \cdot F_{mc} \cdot F_D \cdot f_{core} \cdot \text{Front} \qquad (5)$$

or eq. 15

where f_c is the equivalent in-place concrete cylinder strength, f_{core} is concrete core strength, $F_{l/d}$ is strength correction factor for aspect ratio, F_{dia} is strength correction factors for diameter, F_{mc} is strength correction factor for moisture condition of core sample, and F_D is the strength correction factor that accounts for effect of damage sustained during core drilling including micro-cracking and undulations at the drilled surface and cutting through coarse-aggregate particles that may subsequently pop out during testing.

Table 2 Mean values for factor $F_{l/d}$ according to ACI Code (1998) and ASTM.

	Specimen length-to-diameter ratio, l/d			
	1.00	1.25	1.50	1.75
$F_{l/d}$	0.87	0.93	0.96	0.98

The ACI committee considered the correction factors presented in Table 3 for converting core strengths into equivalent in-place strengths based on the work reported by Bartlett and MacGregor [6]. It should be noted that the magnitude of

Table 3 Strength correction factors according to ACI 214.4R-03.

List	Factors	Mean values
(1)[b]	$F_{l/d}$:l/d ratio	
	As-received	$1 - \{0.130 - \alpha f_{core}\}(2 - \frac{l}{d})^2$
	Soaked 48 h	$1 - \{0.117 - \alpha f_{core}\}\ (2 - \frac{l}{d})^2$
	Air dried[a]	$1 - \{0.144 - \alpha f_{core}\}(2 - \frac{l}{d})^2$
(2)	F_{dia}: core diameter	
	50 mm	1.06
	100 mm	1.00
	150 mm	0.98
(3)	F_{mc}: core moisture content	
	As-received	1.00
	Soaked 48 h	1.09
	Air dried[a]	0.96
(4)	F_D: damage due to drilling	1.06

[a] Standard treatment specified in ASTM C 42/C 42M.

[b] Constant α equals $4.3(10^{-4})$ 1/MPa for f_{core} in MPa.

Table 6 List of comparisons between tested cores to determine.

	A18	A17	A16	A15	A14	A13	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1
A1	♦●	●	♦●	■●	■●		●				●			▲	▲	■	▲	
A2																		
A3						■●				■●								
A4																		
A5																		
A6								■▲●	■▲●			■▲						
A7								■▲●	■▲●									
A8		●	♦	●	●													
A9																		
A10								■▲●										
A11																		
A12		●		●	●													
A13																		
A14		●		●														
A15		●																
A16	●♦																	
A17	♦																	
A18																		

● Diameter of steel bar.
▲ Distance of steel bar from nearly end of core.
■ Number of steel bars and spacing between bars.
♦ Distance of steel bar from vertical axis of specimen.

This brief review indicated that the various proposed relationships for correction factors are all nonlinear. It should be noted that the equations given by the Egyptian Code takes into account most variables that may affect the interpretation of the results; however, the code ignores the deterioration of steel–concrete bond that may occur and also the position of the reinforcement from vertical axis of core specimens.

Weighted nonlinear regression analysis has been performed to determine the factor (F_{reinf}) with the use of the software "SAS" package and "Data Fit." This shows that the correction factor for reinforcement (F_{reinf}) is given by the following expression:

- For cores containing a single bar:

single bar

$$F_{\text{reinf}} = \left[1 + 1.5\frac{[\Phi_r \times r + \Phi_r \times (S/10)]}{\Phi_c * L}\right] \times \frac{1.13}{f_{\text{core}}^{0.015}} \quad (12)$$

- For core specimen containing two bars no further apart than the diameter of the larger bar, only the bar corresponding to the higher value of ($\Phi_r * d$) is considered. If the bars are further apart, their combined effect is assessed by replacing the term ($\Phi_r * r$) by ($\sum \Phi_r * r$ as follows:

multiple bars

$$F_{\text{reinf}} = \left[1 + 1.5\frac{\sum[\Phi_r \times r + \Phi_r \times (S/10)]}{\Phi_c * L}\right] \times \frac{1.13}{f_{\text{core}}^{0.015}} \quad (13)$$

where F_{reinf} is the correction factor for reinforcement, Φ_r is the diameter of the reinforcement, Φ_c is the diameter of the concrete specimen, r is the distance of axis of bar from nearer end of specimen, S is the distance of axis of bar from axis of core specimen, L is the length of the specimen after end preparation by grinding or capping, and f_{core} is the concrete core strength (kg/cm^2).

6.1.6. *Effect of moisture condition of core*

Results of about 100 cores indicate that the strength of cores left to dry in air for 7 days is on average 13% greater than that of cores soaked at least 40 h before testing. The strength of cores with negligible moisture gradient and tested after cutting is found to be 7–9% larger than that of soaked cores as shown in Fig. 20. The authors strongly recommend to use a correction factor accounting for moisture condition (F_m) equals to 1.09 and 0.96, respectively, for cores tested after 48 h soaked in water and for those tested after 7 days dry in air.

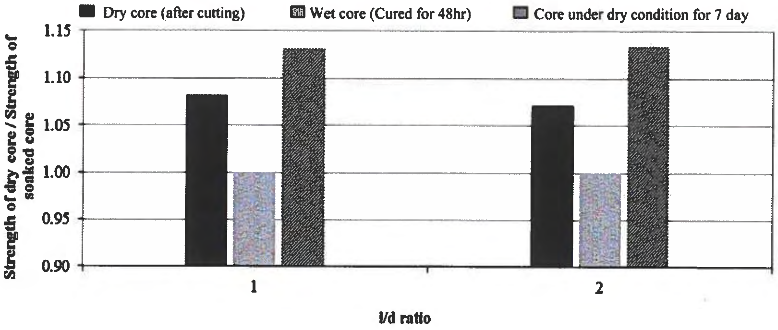


Figure 20 Effect of core moisture condition on core strength for different aspect ratios (l/d).