

APPENDIX 'A'

GEOTECHNICAL REPORT



Quality Engineering | Valued Relationships

WSP Canada Group Ltd.

2023 Local and Industrial Streets Renewal Package (23-R-01)

Prepared for:

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

Project Number: 1000-043-21

Date: December 12, 2022



Quality Engineering | Valued Relationships

December 12, 2022

Our File No. 1000-043-21

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-R-01)

TREK Geotechnical Inc. is pleased to submit our Final Report for the geotechnical investigation for 2023 Local and Industrial Streets Renewal Package (23-R-01) project.

Please contact the undersigned should you have any questions.

Sincerely,

TREK Geotechnical Inc.

Per:

A handwritten signature in blue ink, appearing to read "N. Ferreira".

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


Encl.

Revision History

Revision No.	Author	Issue Date	Description
0	AFK	December 12, 2022	Final Report

Authorization Signatures

Prepared By: _____


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

Reviewed By: _____



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



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1.0 Introduction

This report summarizes the results of the road investigation completed for the Local and Industrial Streets Renewal 23-RI-01 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 29 locations on 11 different local streets with drilling of test holes occurring at 6 of the cored locations along three streets. The investigation locations are shown on Figures 01 to 10 (attached) and the table below summarizes the investigation program per street.

Table I – Road Investigation Program

23-RI-02 Pavement and Geotechnical Investigation	# of Locations	Investigation
Heaton Ave – Waterfront Dr / Argyle St	2	2 test holes to a depths of 3.0 m
Galt Ave – Lily St / Duncan St	2	2 test holes to a depths of 3.0 m
MacDonald Ave – Waterfront Dr / Gomez St	3	2 test holes to a depths of 3.0 m, 1 Core in the parking lane concrete apron
Alexander Ave – Marth St / Lily St	3	3 Cores
McDermot Ave – Myrtle St / McPhillips St	3	3 Cores
Argyle St – George Ave / Disraeli Fr	2	2 Cores
Dagmar St – William Ave / Bannatyne Ave and Bannatyne Ave / McDermot Ave	3	3 Cores
Bentall St – Mountain Ave / Redwood Ave	2	2 Cores
Wyatt Rd – Filkow By / Inkster Blvd and Mandalay Dr / Filkow By	3	3 Cores
Pacific Ave – McPhillips St / Xante St and Xante St / Arlington St	3	3 Cores
Bunting St – Inkster Blvd / Church Ave	3	3 Cores

The road investigation was conducted between November 8, 2022 and November 15, 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 except Heaton Ave which was drilled using a track mounted drill rig. 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 0.9 and 1.1 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 K). 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	Heaton Ave (TH22-02)	1.1-2.7	1529	24.2	95.2	24.0	3.0%	2.4%
Clay	Galt Ave (TH22-03)	0.3-2.0	1519	24.5	95.1	24.9	0.9%	1.5%
Clay	MacDonald Ave (TH22-05)	0.3-3.0	1491	24.8	95.0	25.1	1.3%	1.2%

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.

Thirteen concrete cores were selected for concrete compressive strength breaks and the length to diameter ratio ranged between 1.14 to 1.50 for the cores collected. The core compressive strength tests were tested in accordance with CSA A23.2-14C – wet 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 Appendices D to K.

Table 2: Concrete Core Compressive Strength Results

Core ID (Location)	Uncorrected Compressive Strength (MPa)	Corrected Compressive Strength (MPa)
PC-09 (Alexander Ave)	55.32	69.81
PC-10 (McDermot Ave)	61.72	67.60
PC-13 (Argyle Street)	55.85	61.89
PC-14 (Argyle Street)	52.75	63.33
PC-16 (Dagmar Street)	49.43	52.59
PC-17 (Dagmar Street)	45.35	53.34
PC-18 (Bentall Street)	58.17	63.80
PC-19 (Bentall Street)	57.34	63.14
PC-20 (Wyatt Street)	55.23	64.22
PC-22 (Wyatt Street)	58.83	63.34
PC-23 (Pacific Avenue)	57.06	66.89
PC-26 (Bunting Street)	54.65	63.39
PC-28 (Bunting Street)	62.48	66.10

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\Projects\1000-043 Lab Projects\1000-043-21 2023 Local Streets Package (23-RI-01)\3 Survey and Dwg\3.4 CAD\3.4.3 Working Folder\Fig 01 2022-12-02 LSP23-RI-01 0_A_1000-043-21.dwg, 2022-12-02 10:51:53 AM



LEGEND:

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

NOTES:

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

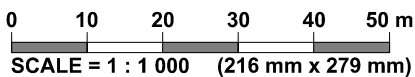
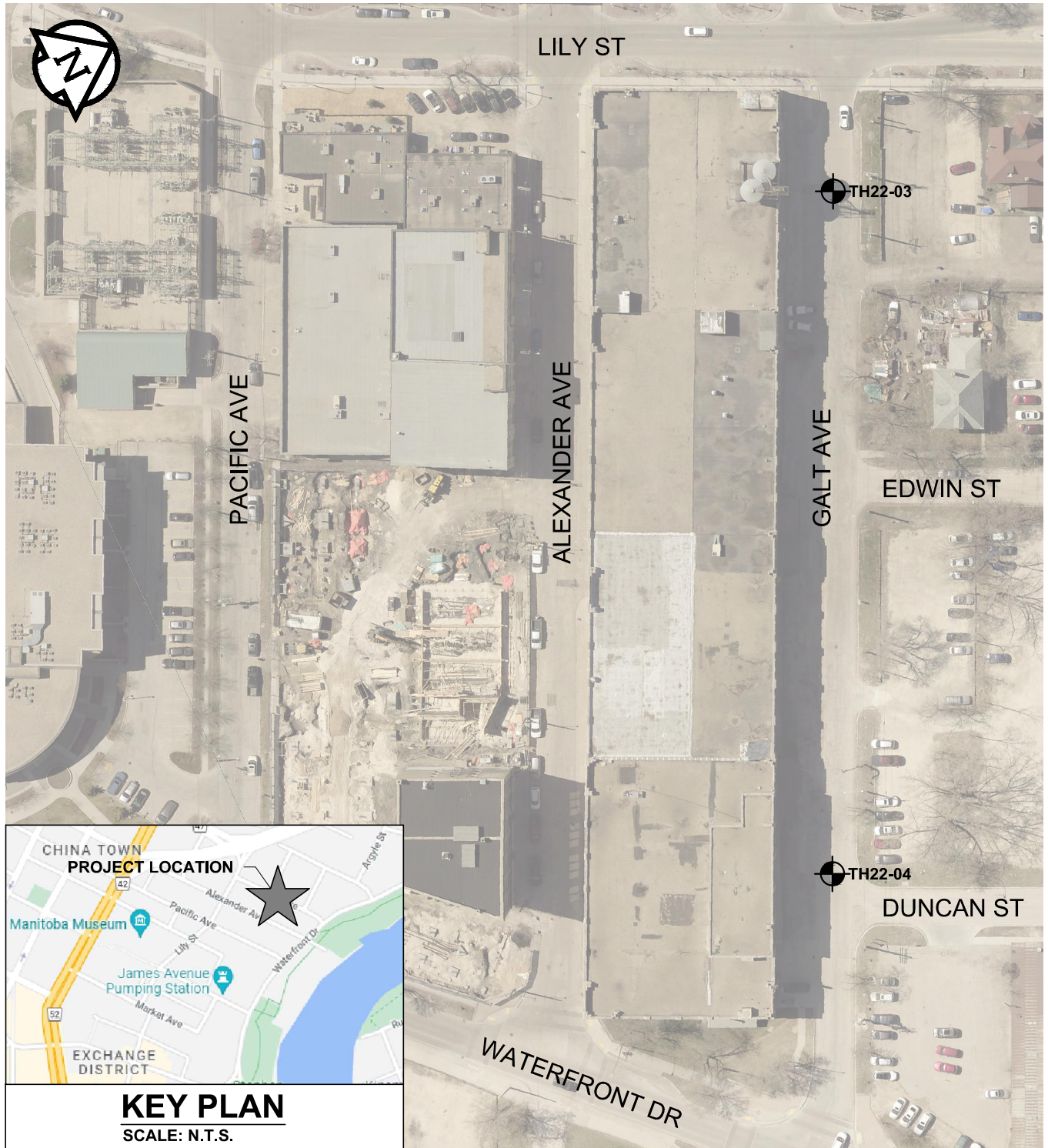


Figure 01
Test Hole and
Pavement Core Location Plan

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LEGEND:

TEST HOLE (TREK, 2022)

NOTES:

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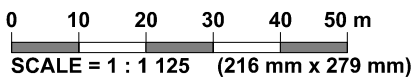




Figure 02
Test Hole Location Plan



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LEGEND:

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

NOTES:

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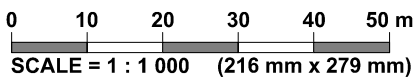
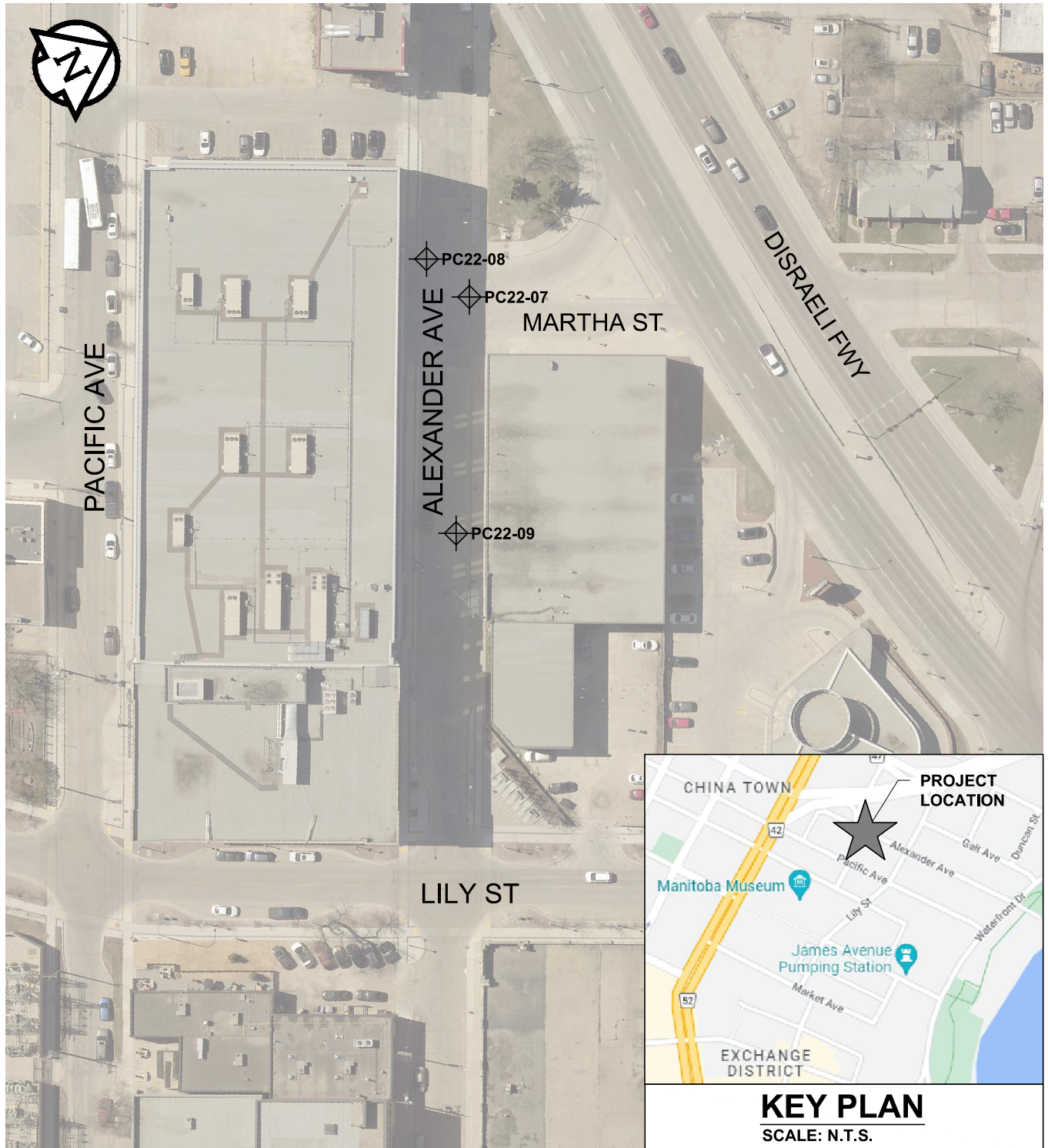


Figure 03
Test Hole and
Pavement Core Location Plan

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LEGEND:

PAVEMENT CORE (TREK, 2022)

NOTES:

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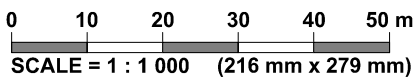


Figure 04
Pavement Core Location Plan

Z:\Projects\1000 Soils Lab\Projects\1000-043 WSP\1000-043-21 2023 Local Streets Package (23-RI-01)\3 Survey and Dwg\3.4 CAD\3.4.3 Working Folder\Fig 05 2022-12-02 LSP23-RI-01 0_A_1000-043-21.dwg, 2022-12-02 11:26:57 AM



LEGEND:

PAVEMENT CORE (TREK, 2022)

NOTES:

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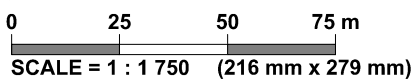


Figure 05
Pavement Core Location Plan

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LEGEND:

PAVEMENT CORE (TREK, 2022)

NOTES:

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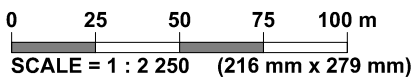


Figure 06
Pavement Core Location Plan

Z:\Projects\1000 Soils Lab\Projects\1000-043 WSP\1000-043-21 2023 Local Streets Package (23-RI-01)\3 Survey and Dwg\3.4 CAD\3.4.3 Working Folder\Fig 07 2022-12-02 LSP23-RI-01_0_A_1000-043-21.dwg, 2022-12-02 1:09:56 PM



LEGEND:

PAVEMENT CORE (TREK, 2022)

NOTES:

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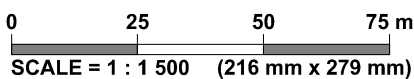
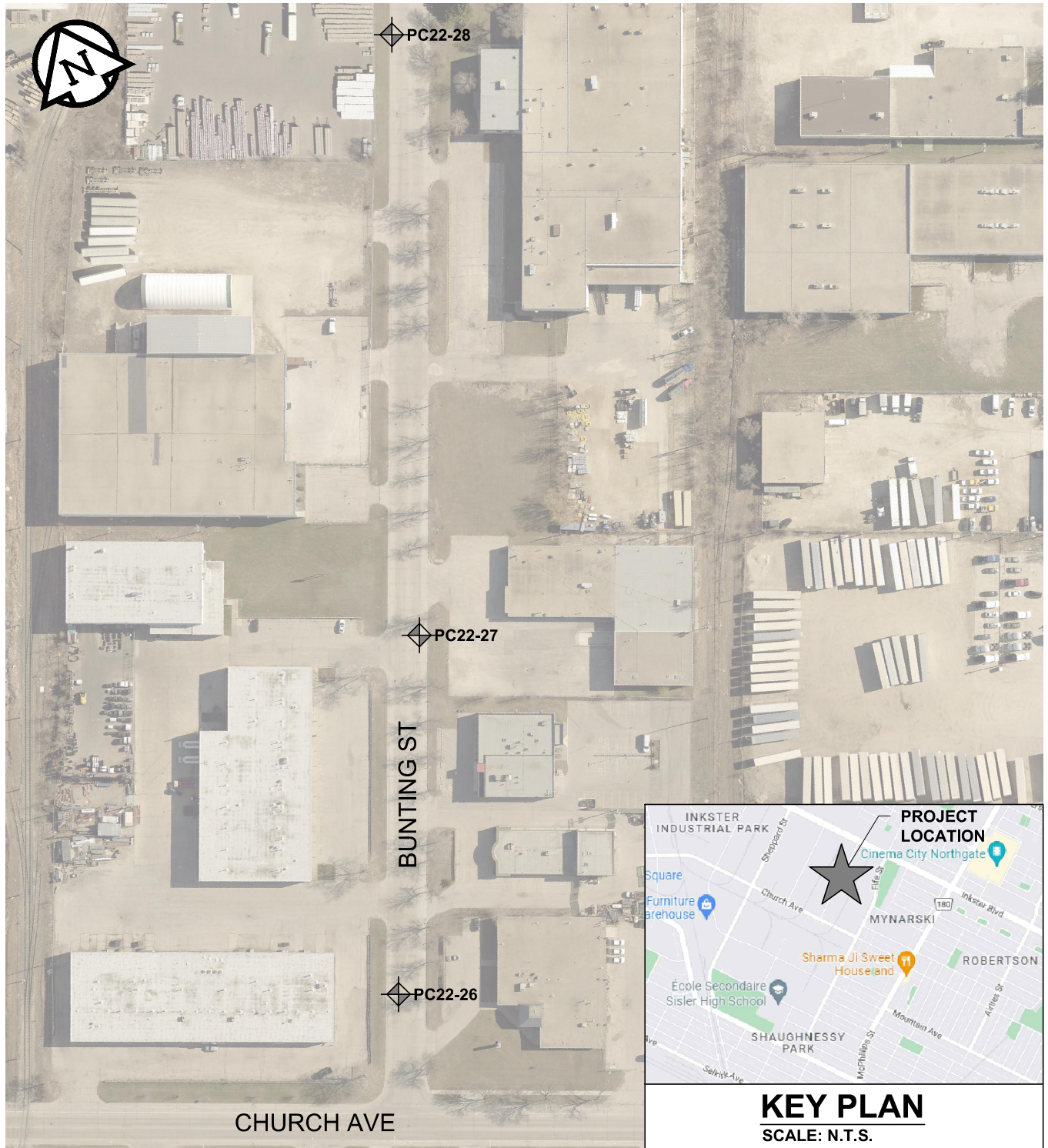


Figure 07
Pavement Core Location Plan

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LEGEND:

PAVEMENT CORE (TREK, 2022)

NOTES:

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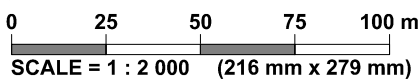
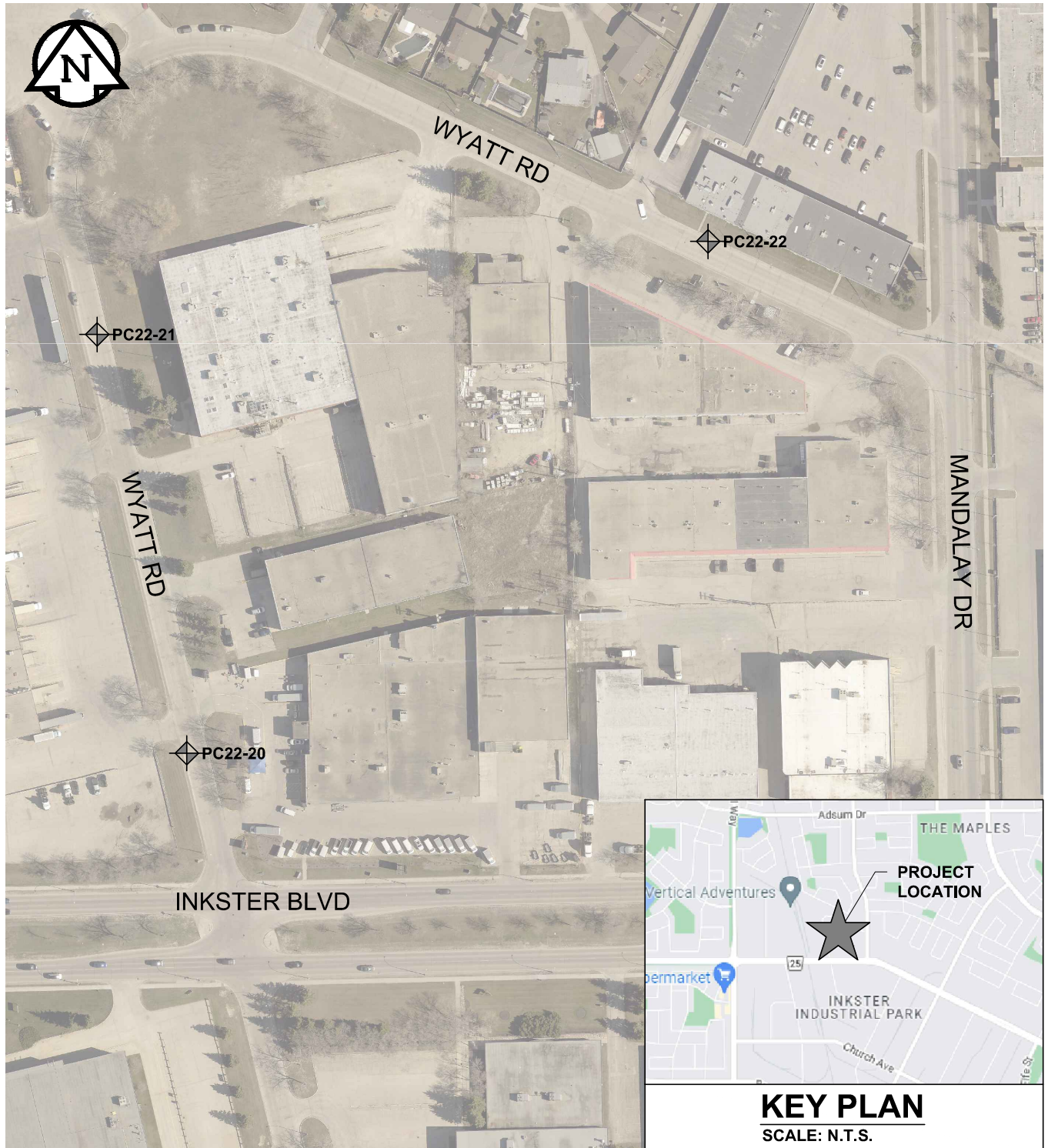


Figure 08
Pavement Core Location Plan

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LEGEND:

PAVEMENT CORE (TREK, 2022)

NOTES:

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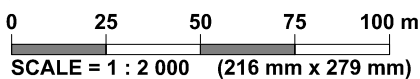


Figure 09
Pavement Core Location Plan

Z:\Projects\1000 Soils Lab\Projects\1000-043 WSP\1000-043-21 2023 Local Streets Package (23-RI-01)\3 Survey and Dwg\3.4 CAD\3.4.3 Working Folder\Fig 10 2022-12-07 LSP23-RI-01 0_A_1000-043-21.dwg, 2022-12-07 8:28:25 AM



LEGEND:

PAVEMENT CORE (TREK, 2022)

NOTES:

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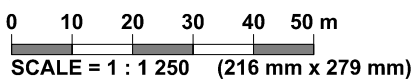


Figure 10
Pavement Core Location Plan

Appendix A

Test Hole Logs, Summary Table & Lab Testing Results and Pavement Core Photos – Heaton Ave

GENERAL NOTES

- 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.
- 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.
- 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		Particle Size					
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)	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 cases 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	ASTM Sieve sizes					
		GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW		#10 to #4 #40 to #10 #200 to #40 < #200				
		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 borderline cases requiring use of dual symbols	mm				
		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	mm				
			SP		Poorly-graded sands, gravelly sands, little or no fines	Not meeting all gradation requirements for SW		2.00 to 4.75 0.425 to 2.00 0.075 to 0.425 < 0.075			
		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 borderline cases requiring use of dual symbols	Material			
			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 Plasticity chart for soil fraction with particles smaller than 0.425 mm	Material
						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	mm									
Silts and Clays (Liquid limit greater than 50)	MH	Inorganic silts, micaceous or distomaceous fine sandy or silty soils, organic silts		> 300	> 12 in.						
	CH	Inorganic clays of high plasticity, fat clays		75 to 300	3 in. to 12 in.						
	OH	Organic clays of medium to high plasticity, organic silts		19 to 75	3/4 in. to 3 in.						
				4.75 to 19	#4 to 3/4 in.						
Highly Organic Soils	Pt	Peat and other highly organic soils		Von Post Classification Limit	Strong colour or odour, and often fibrous texture	Material					
							Boulders Cobbles Gravel Coarse Fine				

* 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

LEGEND OF ABBREVIATIONS AND SYMBOLS

LL - Liquid Limit (%)	▽ Water Level at Time of Drilling
PL - Plastic Limit (%)	▼ Water Level at End of Drilling
PI - Plasticity Index (%)	▽ Water Level After Drilling as Indicated on Test Hole Logs
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	

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:

<u>Descriptive Terms</u>	<u>SPT (N) (Blows/300 mm)</u>
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:

<u>Descriptive Terms</u>	<u>SPT (N) (Blows/300 mm)</u>
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:

<u>Descriptive Terms</u>	<u>Undrained Shear Strength (kPa)</u>
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 (Heaton Ave)

1 of 1

Client: WSP Canada Group Ltd. **Project Number:** 1000-043-21
Project Name: 2023 Local and Industrial Streets Renewal Package (23-RI-01) **Location:** UTM N-5529423, E-634385
Contractor: Maple Leaf Drilling Ltd. **Ground Elevation:** Top of Pavement
Method: 125mm Solid Stem Auger, Scout track mounted rig **Date Drilled:** November 14, 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	Bulk Unit Wt (kN/m ³)						Undrained Shear Strength (kPa)					
					16	17	18	19	20	21	Test Type					
					Particle Size (%)											
					0	20	40	60	80	100						
					PL	MC	LL				0	25	50	75	100	125
0.00 - 0.05		ASPHALT - 55 mm thick		PC22-0												
0.05 - 0.10		CONCRETE - 135 mm thick														
0.10 - 1.60		CLAY - silty, trace sand - greyish black - moist, soft - high plasticity - AASHTO: A-7-6 (42) - stiff below 0.8 m - brown below 1.0 m		G08												
				G09												
				G10												
				G11												
		SILT - clayey, trace sand, brown, moist, soft, low plasticity, AASHTO: A-4 (I)		G12												
		CLAY - silty - brown - moist, stiff - high plasticity - AASHTO: A-7-6 (I)		G13												
				G14												
				G15												

END OF TEST HOLE AT 3.2 m IN CLAY.
 1) Seepage or sloughing not observed.
 2) Test hole open to 3.2 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 #61 Heaton Ave, 2.0 m South of North curb.
 5) The bulk sample was collected between 0.2 m and 3.2 m depth.

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

SUB-SURFACE LOG LOGS 2022-12-09 HEATON AVE 23-R-01.0.D.JSB.1000.043.21.GPJ.TREK.GDT.12/9/22



Sub-Surface Log

Test Hole TH22-02 (Heaton Ave)

1 of 1

Client: WSP Canada Group Ltd. **Project Number:** 1000-043-21
Project Name: 2023 Local and Industrial Streets Renewal Package (23-RI-01) **Location:** UTM N-5529408, E-634444
Contractor: Maple Leaf Drilling Ltd. **Ground Elevation:** Top of Pavement
Method: 125mm Solid Stem Auger, Scout track mounted rig **Date Drilled:** November 14, 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	Bulk Unit Wt (kN/m ³)						Undrained Shear Strength (kPa)					
					16	17	18	19	20	21	Test Type					
					Particle Size (%)											
					0	20	40	60	80	100						
					PL MC LL 0 20 40 60 80 100											
					0	20	40	60	80	100	0	25	50	75	100	125
0.0 - 0.1	ASPHALT	ASPHALT - 160 mm thick	PC22-02													
0.1 - 1.1	SAND AND GRAVEL	SAND AND GRAVEL (FILL) - some clay, trace silt, 25-50 mm down crushed limestone - brown - moist, compact - no to low plasticity - angular - AASHTO: A-1-a (I)	G01													
1.1 - 3.0	CLAY	CLAY - silty, trace sand, trace organics - black - moist, stiff - high plasticity - AASHTO: A-7-6 (51) - no organics, brown below 2.1 m	G02													
			G03													
			G04													
			G05													
			G06													
			G07													
3.0 - 3.2	SILT AND CLAY	SILT AND CLAY - trace sand - brown, moist, soft - low to intermediate plasticity - AASHTO: A-6 (I)														

END OF TEST HOLE AT 3.2 m IN SILT AND CLAY.
 1) Seepage not observed.
 2) Sloughing observed from top surface.
 3) Test hole open to 2.7 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 south face of #530 Waterfront Dr, 2.0 m North of South curb.
 6) The bulk sample was collected between 1.1 m and 2.7 m depth.

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

SUB-SURFACE LOG LOGS 2022-12-09 HEATON AVE 23-R-01.0.D.JSB.1000.043.21.GPJ.TREK.GDT.12/9/22



2023 Local and Industrial Streets Renewal Project - 23-RI-01
Sub-Surface Investigation
Heaton Ave - Waterfront Dr / Argyle St

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 5529423 N 634385E Located in front of #61 Heaton Ave, 2.0 m South of North curb.	Asphalt	55	Concrete	135	Clay; AASHTO: A-7-6 (42)	0.3	0.5	38								
						Clay; AASHTO: A-7-6 (42)	0.8	0.9	34								
						Clay; AASHTO: A-7-6 (42)	1.0	1.2	38	61	37	2.0	0.0	23	60	38	
						Clay; AASHTO: A-7-6 (42)	1.4	1.5	35								
						Silt; AASHTO: A-4 (I)	1.6	1.7	40								
						Clay; AASHTO: A-7-6 (I)	1.8	2.0	46								
						Clay; AASHTO: A-7-6 (I)	2.1	2.3	49								
						Clay; AASHTO: A-7-6 (I)	2.7	3.0	53								
TH22-02	UTM: 14U 5529408N, 634444 E Located in front of south access of #530 Waterfront Dr, 2.0 m North of South curb.	Asphalt	160	Concrete	-	Sand And Gravel (Fill); AASHTO: A-1-a (I)	0.2	1.1	5								
						Clay; AASHTO: A-7-6 (51)	1.1	1.2	32	52	41	6	1	25	73	48	
						Clay; AASHTO: A-7-6 (51)	1.4	1.5	32								
						Clay; AASHTO: A-7-6 (51)	1.7	1.8	32								
						Clay; AASHTO: A-7-6 (51)	2.1	2.3	28								
						Clay; AASHTO: A-7-6 (51)	2.4	2.6	30								
						Silt and Clay; AASHTO: A-6 (I)	2.7	3.0	23								

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



Project No. 1000-043-21
Client WSP Canada Group LTD
Project 2023 Local and Industrial Streets Package (23-RI-01) - Heaton Ave

Sample Date 14-Nov-22
Test Date 22-Nov-22
Technician TG

Test Hole	TH22-01	TH22-01	TH22-01	TH22-01	TH22-01	TH22-01
Depth (m)	0.3 - 0.5	0.8 - 0.9	1.0 - 1.2	1.4 - 1.5	1.6 - 1.7	1.8 - 2.0
Sample #	G08	G09	G10	G11	G12	G13
Tare ID	AB08	E8	Z29	F71	E19	E60
Mass of tare	6.9	8.5	8.6	8.5	8.5	8.6
Mass wet + tare	262.5	276.0	400.0	257.5	274.5	272.9
Mass dry + tare	192.6	208.5	292.6	192.4	199.0	189.9
Mass water	69.9	67.5	107.4	65.1	75.5	83.0
Mass dry soil	185.7	200.0	284.0	183.9	190.5	181.3
Moisture %	37.6%	33.8%	37.8%	35.4%	39.6%	45.8%

Test Hole	TH22-01	TH22-01	TH22-02	TH22-02	TH22-02	TH22-02
Depth (m)	2.1 - 2.3	2.7 - 3.0	0.2 - 1.1	1.1 - 1.2	1.4 - 1.5	1.7 - 1.8
Sample #	G14	G15	G01	G02	G03	G04
Tare ID	F86	F32	W92	AB90	A17	N04
Mass of tare	8.3	8.4	8.5	6.9	8.7	8.7
Mass wet + tare	265.3	252.6	363.0	387.5	277.1	283.7
Mass dry + tare	180.7	168.1	345.5	295.0	211.6	217.1
Mass water	84.6	84.5	17.5	92.5	65.5	66.6
Mass dry soil	172.4	159.7	337.0	288.1	202.9	208.4
Moisture %	49.1%	52.9%	5.2%	32.1%	32.3%	32.0%

Test Hole	TH22-02	TH22-02	TH22-02			
Depth (m)	2.1 - 2.3	2.4 - 2.6	2.7 - 3.0			
Sample #	G05	G06	G07			
Tare ID	W04	Z132	C8			
Mass of tare	8.5	8.7	8.4			
Mass wet + tare	301.5	252.7	333.0			
Mass dry + tare	237.7	196.3	273.0			
Mass water	63.8	56.4	60.0			
Mass dry soil	229.2	187.6	264.6			
Moisture %	27.8%	30.1%	22.7%			



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Atterberg Limits
ASTM D4318-10e1

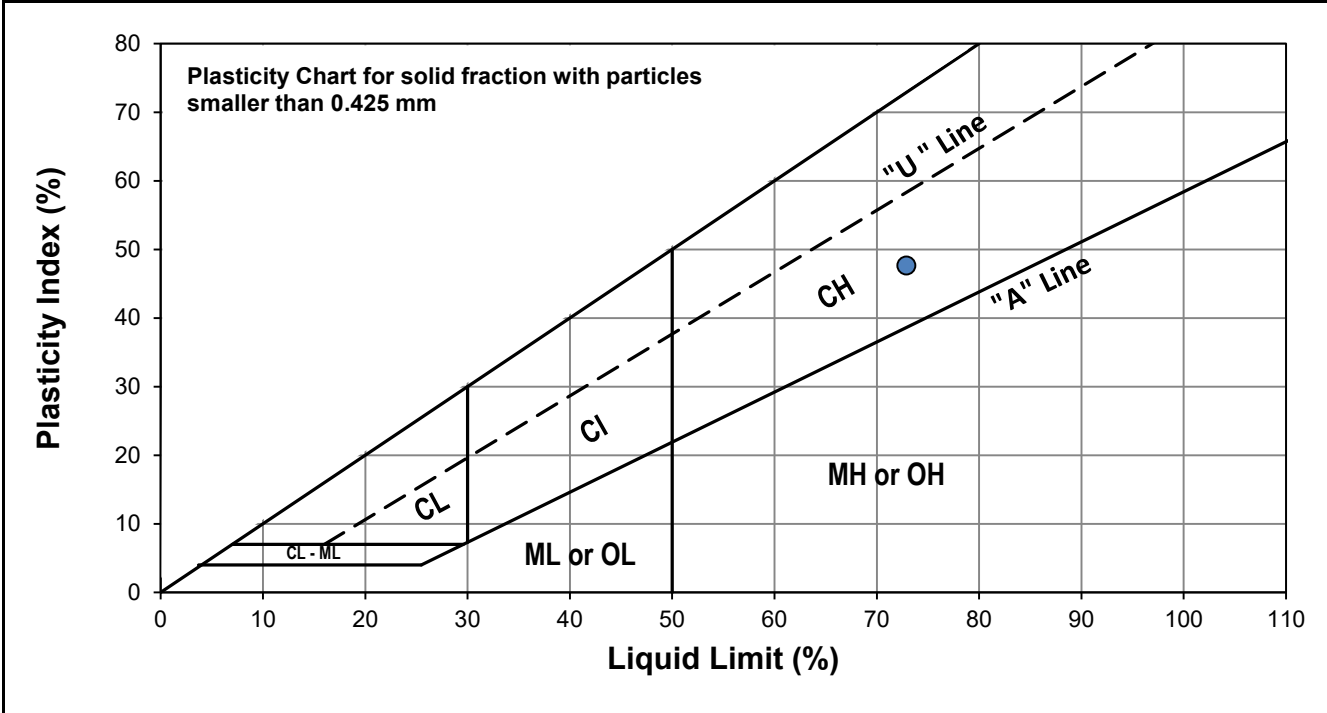
Project No. 1000-043-21
Client WSP Canada Group LTD
Project 2023 Local and Industrial Streets Package (23-RI-01) - Heaton Ave
Test Hole TH22-02
Sample # G02
Depth (m) 1.1 - 1.2
Sample Date 14-Nov-22
Test Date 28-Nov-22
Technician MT



Liquid Limit	73
Plastic Limit	25
Plasticity Index	48

Liquid Limit

Trial #	1	2	3
Number of Blows (N)	15	23	34
Mass Tare (g)	13.885	14.280	14.055
Mass Wet Soil + Tare (g)	25.019	24.064	22.827
Mass Dry Soil + Tare (g)	20.107	19.908	19.236
Mass Water (g)	4.912	4.156	3.591
Mass Dry Soil (g)	6.222	5.628	5.181
Moisture Content (%)	78.946	73.845	69.311



Plastic Limit

Trial #	1	2	3	4	5
Mass Tare (g)	13.977	14.119			
Mass Wet Soil + Tare (g)	24.505	23.871			
Mass Dry Soil + Tare (g)	22.376	21.907			
Mass Water (g)	2.129	1.964			
Mass Dry Soil (g)	8.399	7.788			
Moisture Content (%)	25.348	25.218			

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



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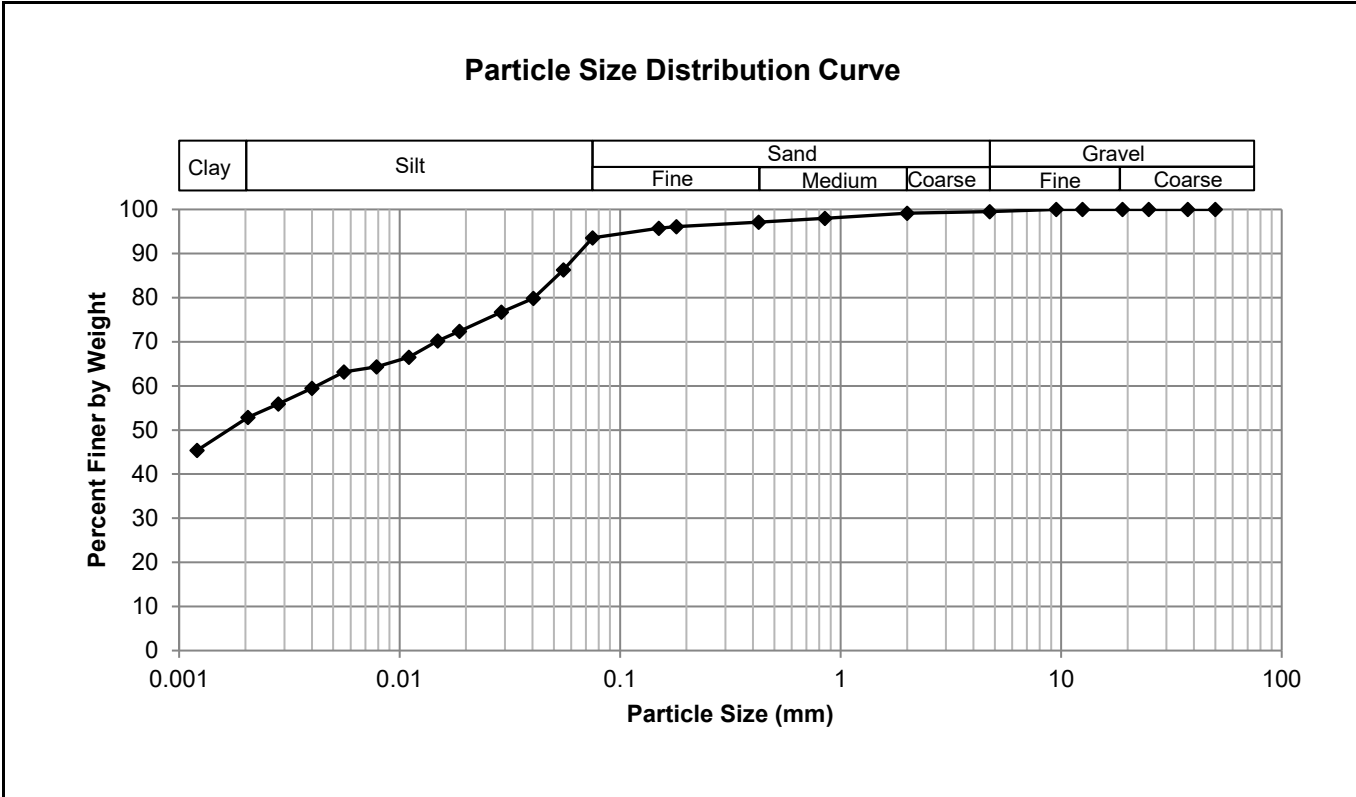
Grain Size Analysis (Hydrometer Method)
AASHTO T 88

Project No. 1000-043-21
Client WSP Canada Group LTD
Project 2023 Local and Industrial Streets Package (23-RI-01) - Heaton Ave

Test Hole TH22-02
Sample # G02
Depth (m) 1.1 - 1.2
Sample Date 14-Nov-22
Test Date 30-Nov-22
Technician TG



Gravel	0.5%
Sand	5.9%
Silt	41.2%
Clay	52.4%



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	99.53	0.0750	93.59
37.5	100.00	2.00	99.14	0.0554	86.33
25.0	100.00	0.850	97.97	0.0404	79.82
19.0	100.00	0.425	97.11	0.0290	76.72
12.5	100.00	0.180	96.07	0.0187	72.38
9.50	100.00	0.150	95.77	0.0149	70.21
4.75	99.53	0.075	93.59	0.0110	66.49
				0.0079	64.32
				0.0056	63.15
				0.0040	59.43
				0.0028	55.95
				0.0021	52.85
				0.0012	45.38



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Atterberg Limits
ASTM D4318-10e1

Project No. 1000-043-21
Client WSP Canada Group LTD
Project 2023 Local and Industrial Streets Package (23-RI-01) - Heaton Ave

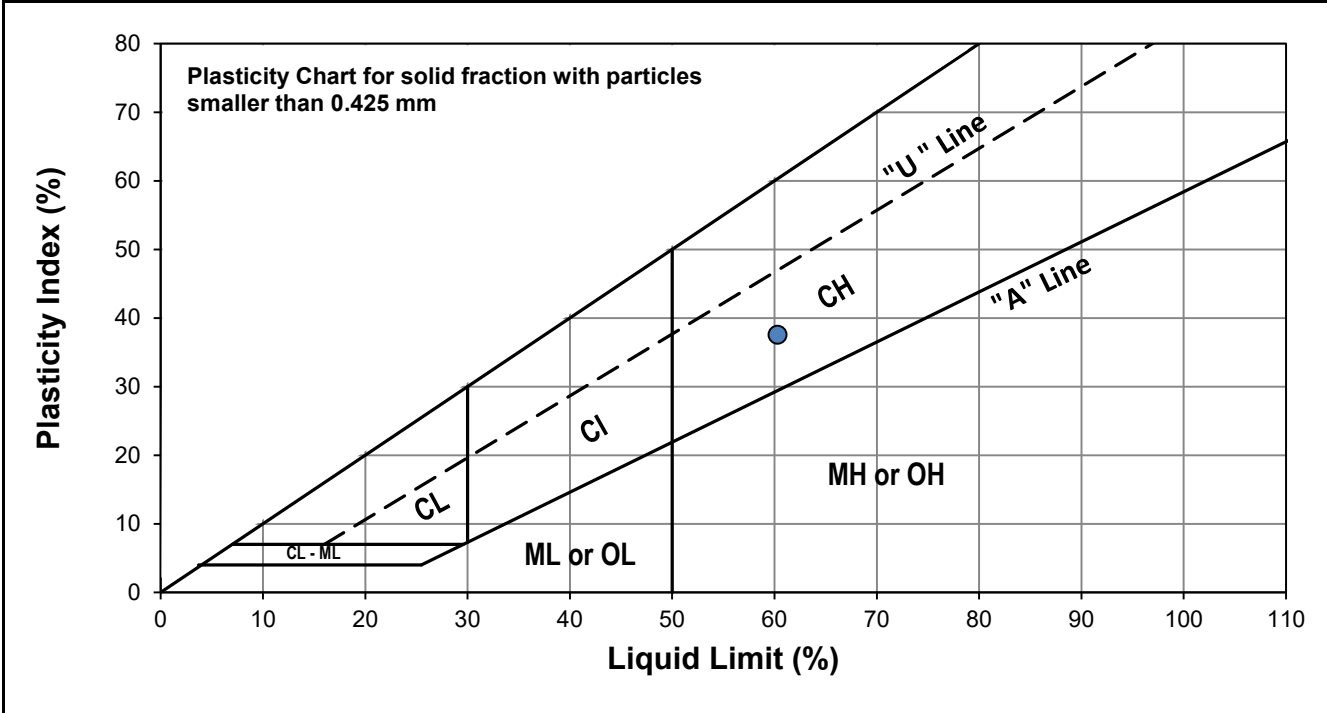
Test Hole TH22-01
Sample # G10
Depth (m) 1.0 - 1.2
Sample Date 14-Nov-22
Test Date 29-Nov-22
Technician MT



Liquid Limit	60
Plastic Limit	23
Plasticity Index	38

Liquid Limit

Trial #	1	2	3
Number of Blows (N)	16	22	33
Mass Tare (g)	14.097	14.263	13.885
Mass Wet Soil + Tare (g)	23.728	23.518	22.791
Mass Dry Soil + Tare (g)	19.965	19.998	19.524
Mass Water (g)	3.763	3.520	3.267
Mass Dry Soil (g)	5.868	5.735	5.639
Moisture Content (%)	64.127	61.378	57.936



Plastic Limit

Trial #	1	2	3	4	5
Mass Tare (g)	13.953	14.203			
Mass Wet Soil + Tare (g)	20.690	20.222			
Mass Dry Soil + Tare (g)	19.454	19.095			
Mass Water (g)	1.236	1.127			
Mass Dry Soil (g)	5.501	4.892			
Moisture Content (%)	22.469	23.038			

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



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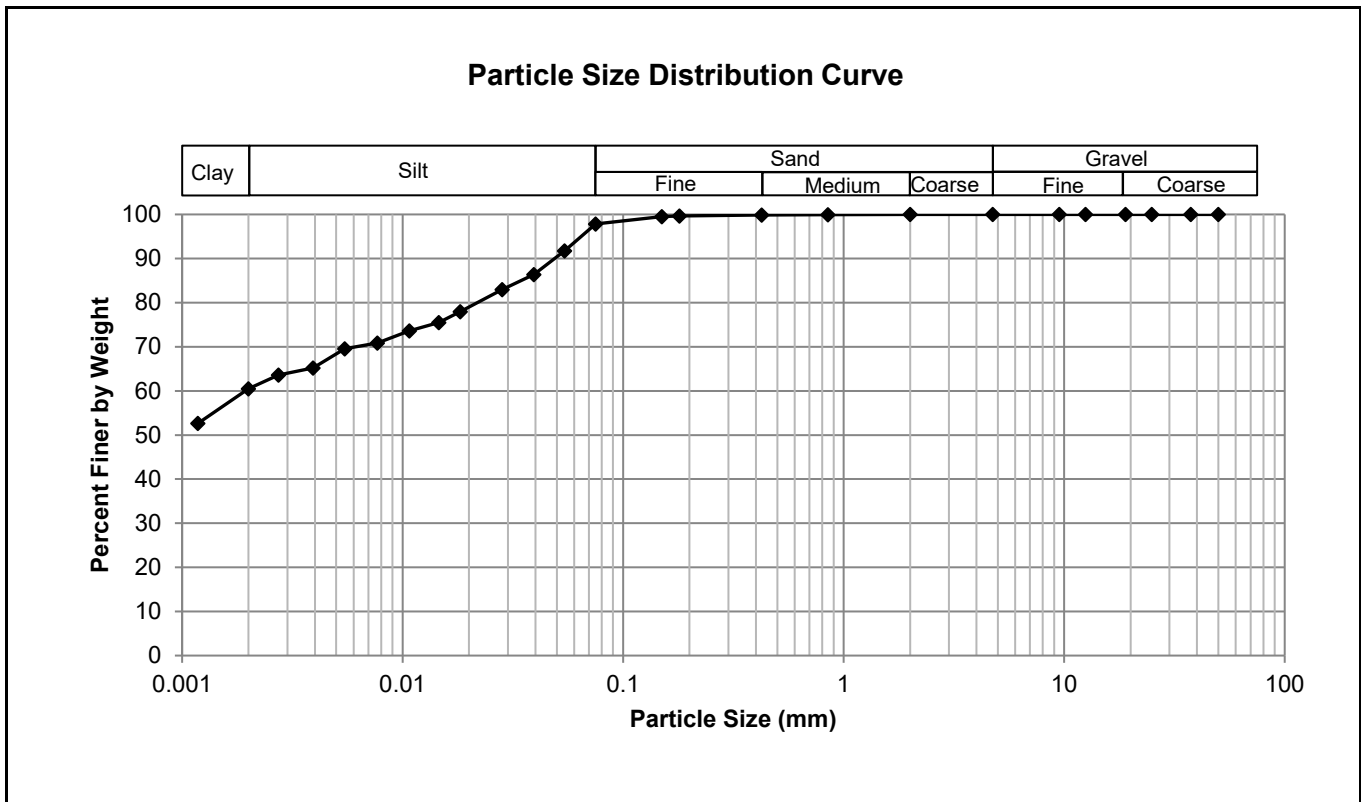
Grain Size Analysis (Hydrometer Method)
AASHTO T 88

Project No. 1000-043-21
Client WSP Canada Group LTD
Project 2023 Local and Industrial Streets Package (23-RI-01) - Heaton Ave

Test Hole TH22-01
Sample # G10
Depth (m) 1.0 - 1.2
Sample Date 14-Nov-22
Test Date 30-Nov-22
Technician TG



Gravel	0.0%
Sand	2.2%
Silt	37.4%
Clay	60.4%



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	97.81
37.5	100.00	2.00	100.00	0.0542	91.73
25.0	100.00	0.850	99.97	0.0393	86.41
19.0	100.00	0.425	99.89	0.0282	82.97
12.5	100.00	0.180	99.63	0.0183	77.97
9.50	100.00	0.150	99.51	0.0146	75.47
4.75	100.00	0.075	97.81	0.0107	73.59
				0.0077	70.82
				0.0055	69.57
				0.0039	65.19
				0.0027	63.59
				0.0020	60.46
				0.0012	52.63



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Standard Proctor Compaction Test

ASTM D698-12 (2021)

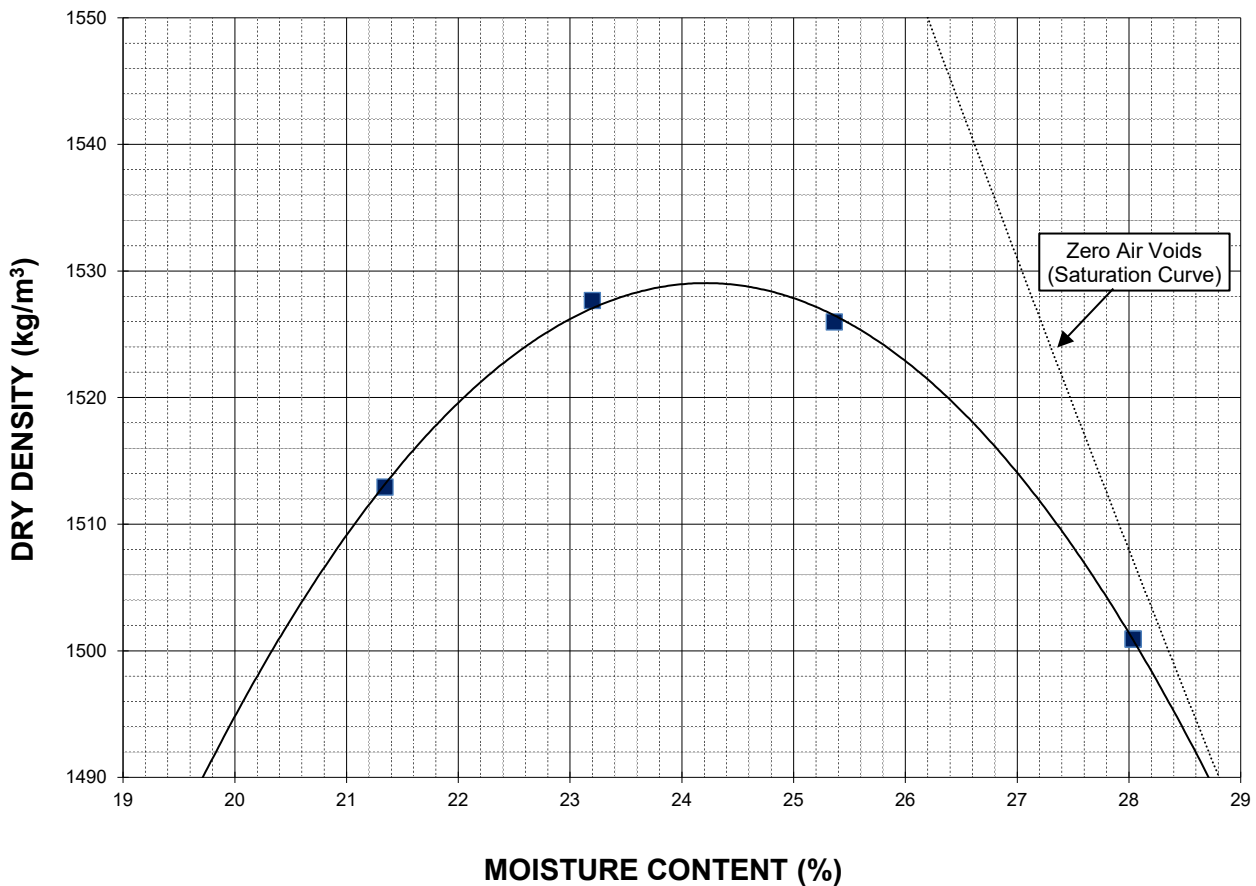


Project No. 1000-043-21
Client WSP Canada Group LTD
Project 2023 Local and Industrial Streets Package (23-RI-01)

Sample # TH22-02
Source Heaton Ave
Material Clay
Sample Date 14-Nov-22
Test Date 23-Nov-22
Technician DS

Maximum Dry Density (kg/m³)	1529
Optimum Moisture (%)	24.2

Trial Number	1	2	3	4	
Wet Density (kg/m³)	1836	1882	1913	1922	
Dry Density (kg/m³)	1513	1528	1526	1501	
Moisture Content (%)	21.3	23.2	25.4	28.0	



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



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California Bearing Ratio Test Data Sheet
ASTM D1883-16

Project No.	1000-043-21	Source	Heaton Ave.
Client	WSP Canada Group LTD	Material	Clay
Project	2023 Local Streets (23-RI-01)	Sample Date	2022-11-14
Sample #	TH22-02	Test Date	2022-11-25
		Technician	DS

Proctor Results (ASTM D698)

Maximum Dry Density	1529 kg/m3
Optimum Moisture Content	24.2 %
Material Retained on 19 mm Sieve	0.0 %

CBR Sample Compaction

Dry Density	1456 kg/m3
Initial Moisture Content	24.0 %
Relative Density	95.2 % SPMDD

Soaking Results

Surcharge	4.54 kg
Swell	1.6 %
Moisture Content in top 25 mm	33.3 %
Immersion Period	96 h

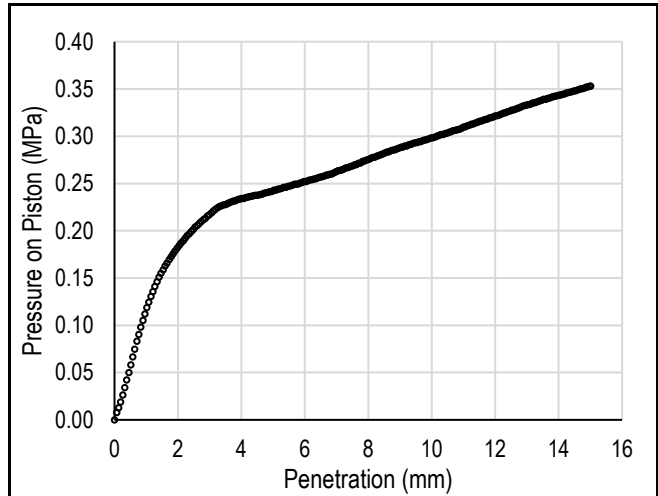
CBR Results

CBR at 2.54 mm	3.0 %
CBR at 5.08 mm	2.4 %
Zero Correction	0 mm

Test Data

Penetration (mm)	Measured Pressure (MPa)	Corrected Pressure (MPa)
0.64	0.08	0.08
1.27	0.14	0.14
1.91	0.18	0.18
2.54	0.20	0.20
3.18	0.22	0.22
3.81	0.23	0.23
4.45	0.24	0.24
5.08	0.24	0.24
7.62	0.27	0.27
10.16	0.30	0.30
12.70	0.33	0.33

Load/Penetration Curve



Comments:

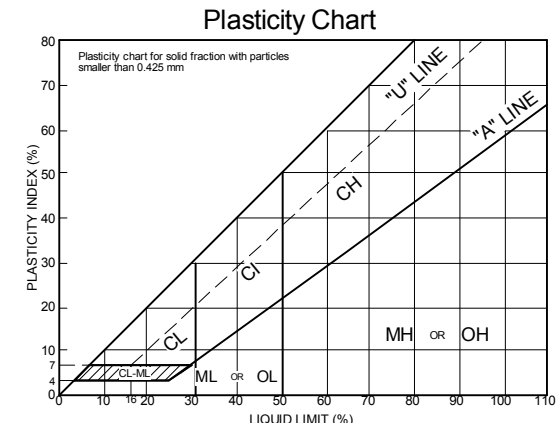
Appendix B

Test Hole Logs, Summary Table & Lab Testing Results and Pavement Core Photos – Galt Ave

GENERAL NOTES

- 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.
- 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.
- 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		Particle Size	Material		
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)	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 cases 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	ASTM Sieve sizes	#10 to #4 #40 to #10 #200 to #40 < #200		
		GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW				
		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 borderline 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	mm	2.00 to 4.75 0.425 to 2.00 0.075 to 0.425 < 0.075	
			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 borderline cases requiring use of dual symbols	Material	Sand Coarse Medium Fine Silt or Clay
			SC		Clayey sands, sand-clay mixtures	Atterberg limits above "A" line or P.I. greater than 7			



* 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

LEGEND OF ABBREVIATIONS AND SYMBOLS

LL - Liquid Limit (%)	▽ Water Level at Time of Drilling
PL - Plastic Limit (%)	▼ Water Level at End of Drilling
PI - Plasticity Index (%)	▽ Water Level After Drilling as Indicated on Test Hole Logs
MC - Moisture Content (%)	
SPT - Standard Penetration Test	
RQD- Rock Quality Designation	
Qu - Unconfined Compression	
Su - Undrained Shear Strength	
VW - Vibrating Wire Piezometer	
SI - Slope Incliner	

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:

<u>Descriptive Terms</u>	<u>SPT (N) (Blows/300 mm)</u>
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:

<u>Descriptive Terms</u>	<u>SPT (N) (Blows/300 mm)</u>
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:

<u>Descriptive Terms</u>	<u>Undrained Shear Strength (kPa)</u>
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 TH22-03 (Galt Ave)

1 of 1

Client: WSP Canada Group Ltd. **Project Number:** 1000-043-21
Project Name: 2023 Local and Industrial Streets Renewal Package (23-RI-01) **Location:** UTM N-5529304, E-634057
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	Bulk Unit Wt (kN/m ³)						Undrained Shear Strength (kPa)				
					16	17	18	19	20	21	Test Type				
					Particle Size (%)										
					0	20	40	60	80	100					
					PL MC LL 0 20 40 60 80 100										
					0 20 40 60 80 100						0 25 50 75 100/125				
0.0		ASPHALT - 120 mm thick		PC22-03											
0.0		SAND AND GRAVEL (FILL) - trace silt, 25-50 mm down crushed limestone - brown, moist, compact, no to low plasticity, angular, AASHTO: A-1-a (I)		G68		●									
0.0		CLAY - silty, trace silt inclusions (< 10 mm diam.) - brown - moist, stiff - high plasticity - AASHTO: A-7-6 (57)		G69			●								△
0.0				G70											△
0.0				G71			●								△
0.0				G72			●								+
2.0		SILT - clayey - brown, moist, soft - low plasticity - AASHTO: A-4 (I)		G73		●									△
2.0		CLAY - silty, trace silt inclusions (< 10 mm diam.), trace gravel (< 20 mm diam.) - brown - moist, stiff - high plasticity - AASHTO: A-7-6 (I)		G74			●								+
3.0				G75			●								+

END OF TEST HOLE AT 3.2 m IN CLAY.

- 1) Seepage or sloughing not observed.
- 2) Test hole open to 3.2 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 #18 Galt Ave, 1.2 m North of South edge of road.
- 5) The bulk sample was collected between 0.3 to 2.0 m and 2.3 to 3.0 m depth.

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

SUB-SURFACE LOG LOGS 2022-12-09 GALT AVE 23-R-01 0 D USB 1000 043 21.GPJ TREK GDT 12/9/22



Sub-Surface Log

Test Hole TH22-04 (Galt Ave)

1 of 1

Client: WSP Canada Group Ltd. Project Number: 1000-043-21
 Project Name: 2023 Local and Industrial Streets Renewal Package (23-RI-01) Location: UTM N-5529249, E-634177
 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	Bulk Unit Wt (kN/m ³)						Undrained Shear Strength (kPa)					
					16	17	18	19	20	21	Test Type					
					Particle Size (%)											
					0	20	40	60	80	100						
					PL MC LL 0 20 40 60 80 100											
					0	20	40	60	80	100	0	25	50	75	100	125
0.0 - 0.15		ASPHALT - 165 mm thick		PC22-04												
0.15 - 0.65		SAND AND GRAVEL (FILL) - trace silt, 25-50 mm down crushed limestone - brown - moist, compact - no to low plasticity - angular - AASHTO: A-1-a (I)		G60												
0.65 - 1.0		SAND - trace silt, some gravel (< 50 mm diam.) - brown - moist, compact - no to low plasticity - poorly graded - fine to coarse sand - AASHTO: A-3		G61												
1.0 - 1.1				G62												
1.1 - 1.2				G63												
1.2 - 1.3				G64												
1.3 - 1.4				G65												
1.4 - 1.5				G66												
1.5 - 1.6				G67												
1.6 - 2.5		CLAY - silty, trace silt inclusions (< 10 mm diam.) - brown - moist, firm to stiff - high plasticity - AASHTO: A-7-6 (I)		G66												
2.5 - 3.0				G67												

END OF TEST HOLE AT 3.2 m IN CLAY.
 1) Seepage observed below 1.5 m depth.
 2) Sloughing not observed.
 3) Test hole open to 3.2 m depth and 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 #130 Galt Ave, 0.9 m North of South edge of road.

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

SUB-SURFACE LOG LOGS 2022-12-09 GALT AVE 23-R-01 0 D JSB 1000 043 21 GPT TREK GDT 12/9/22



2023 Local and Industrial Streets Renewal Project - 23-RI-01
Sub-Surface Investigation
Galt Ave - Lily St / Ducan St

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
TH22-03	UTM: 14U 5529304 N 634057E Located in front of #18 Galt Ave, 1.2 m North of South edge of road.	Asphalt	120	Concrete	-	Sand and Gravel (Fill); AASHTO: A-1-a (I)	0.2	0.3	13							
						Clay; AASHTO: A-7-6 (57)	0.8	0.9	32							
						Clay; AASHTO: A-7-6 (57)	1.1	1.2	31	67	30	3.0	0.0	23	75	52
						Clay; AASHTO: A-7-6 (57)	1.4	1.5	29							
						Clay; AASHTO: A-7-6 (57)	1.7	1.8	33							
						Silt; AASHTO: A-4 (I)	2.0	2.3	27							
						Clay; AASHTO: A-7-6 (I)	2.3	2.6	41							
						Clay; AASHTO: A-7-6 (I)	2.9	3.0	40							
TH22-04	UTM: 14U 5529249N, 634177 E Located in front of #130 Galt Ave, 0.9 m North of South edge of road.	Asphalt	165	Concrete	-	Sand and Gravel (Fill); AASHTO: A-1-a (I)	0.2	0.7	4							
						Sand; AASHTO: A-3	0.7	0.9	6							
						Sand; AASHTO: A-3	1.1	1.2	6	5	28	53	14	-	-	NP
						Sand; AASHTO: A-3	1.4	1.5	7							
						Sand; AASHTO: A-3	1.7	1.8	8							
						Sand; AASHTO: A-3	2.1	2.3	13							
						Clay; AASHTO: A-7-6 (I)	2.4	2.7	43							
						Clay; AASHTO: A-7-6 (I)	2.7	3.0	45							

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



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Moisture Content Report ASTM D2216-10

Project No. 1000-043-21
Client WSP Canada Group LTD
Project 2023 Local and Industrial Streets Package (23-RI-01) - Galt Ave

Sample Date 14-Nov-22
Test Date 22-Nov-22
Technician TG

Test Hole	TH22-03	TH22-03	TH22-03	TH22-03	TH22-03	TH22-03
Depth (m)	0.2 - 0.3	0.8 - 0.9	1.1 - 1.2	1.4 - 1.5	1.7 - 1.8	2.0 - 2.3
Sample #	G68	G69	G70	G71	G72	G73
Tare ID	W15	N72	E38	Z63	H03	N12
Mass of tare	8.4	8.9	8.5	8.5	8.6	8.7
Mass wet + tare	398.5	265.0	401.4	243.3	283.4	291.0
Mass dry + tare	355.0	203.2	309.1	190.5	214.9	231.8
Mass water	43.5	61.8	92.3	52.8	68.5	59.2
Mass dry soil	346.6	194.3	300.6	182.0	206.3	223.1
Moisture %	12.6%	31.8%	30.7%	29.0%	33.2%	26.5%

Test Hole	TH22-03	TH22-03	TH22-04	TH22-04	TH22-04	TH22-04
Depth (m)	2.3 - 2.6	2.9 - 3.0	0.2 - 0.7	0.7 - 0.9	1.1 - 1.2	1.4 - 1.5
Sample #	G74	G75	G60	G61	G62	G63
Tare ID	F52	N58	E141	AA19	W77	E470
Mass of tare	8.5	8.4	8.7	6.8	8.6	8.6
Mass wet + tare	251.9	277.2	324.3	338.6	524.5	321.9
Mass dry + tare	180.8	200.3	312.7	320.1	494.6	301.3
Mass water	71.1	76.9	11.6	18.5	29.9	20.6
Mass dry soil	172.3	191.9	304.0	313.3	486.0	292.7
Moisture %	41.3%	40.1%	3.8%	5.9%	6.2%	7.0%

Test Hole	TH22-04	TH22-04	TH22-04	TH22-04		
Depth (m)	1.7 - 1.8	2.1 - 2.3	2.4 - 2.7	2.7 - 3.0		
Sample #	G64	G65	G66	G67		
Tare ID	W79	Z101	P21	W94		
Mass of tare	8.7	8.4	8.5	8.5		
Mass wet + tare	348.9	402.6	270.8	282.7		
Mass dry + tare	323.0	357.6	191.6	197.9		
Mass water	25.9	45.0	79.2	84.8		
Mass dry soil	314.3	349.2	183.1	189.4		
Moisture %	8.2%	12.9%	43.3%	44.8%		



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Atterberg Limits
ASTM D4318-17e1

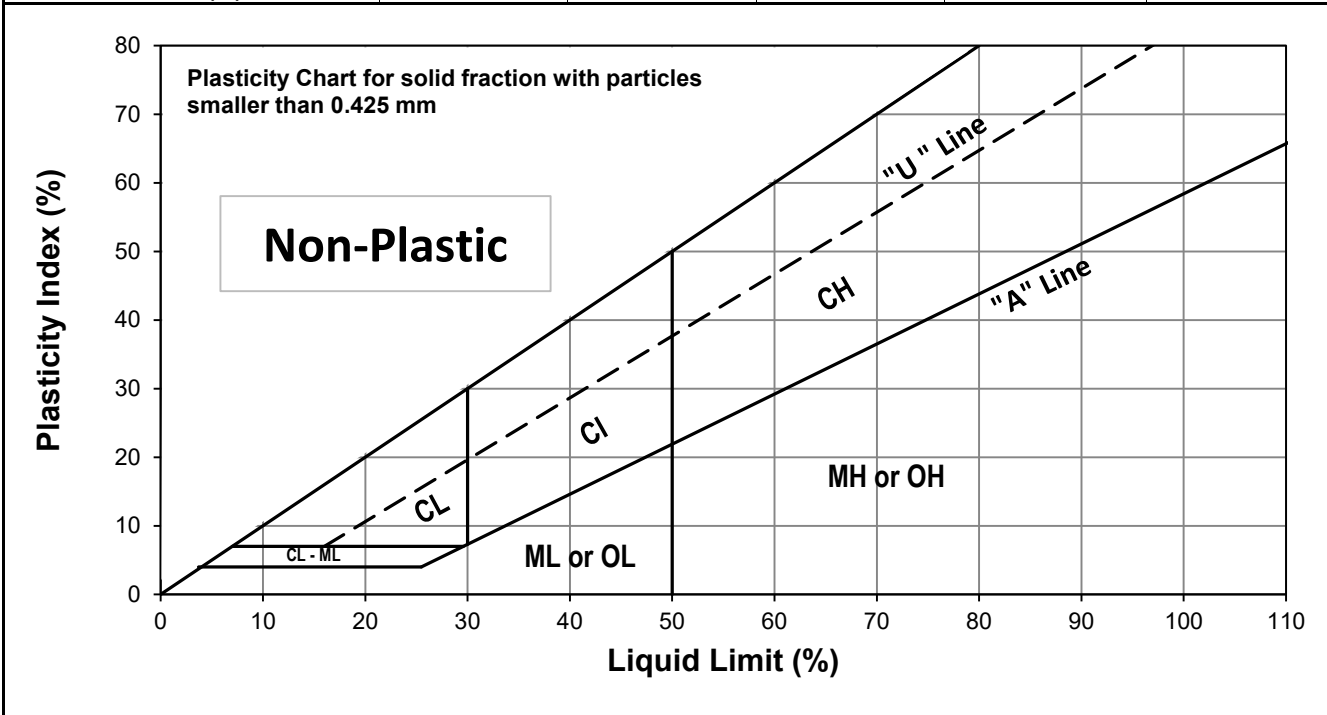
Project No. 1000-043-21
Client WSP Canada Group LTD
Project 2023 Local and Industrial Streets Package (23-RI-01) - Galt Ave
Test Hole TH22-04
Sample # G62
Depth 1.1 - 1.2
Sample Date 15-Nov-22
Test Date 24-Nov-22
Technician SL



Liquid Limit -
Plastic Limit -
Plasticity Index NP

Liquid Limit

Trial #	1	2	3	4	5
Number of Blows (N)	11				
Mass Tare (g)	14.208				
Mass Wet Soil + Tare (g)	32.448				
Mass Dry Soil + Tare (g)	30.306				
Mass Water (g)	2.142				
Mass Dry Soil (g)	16.098				
Moisture Content (%)	13.306				



Plastic Limit

Trial #	1	2	3	4	5
Mass Tare (g)					
Mass Wet Soil + Tare (g)					
Mass Dry Soil + Tare (g)					
Mass Water (g)					
Mass Dry Soil (g)					
Moisture Content (%)					

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



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Grain Size Analysis (Hydrometer Method)
AASHTO T 88

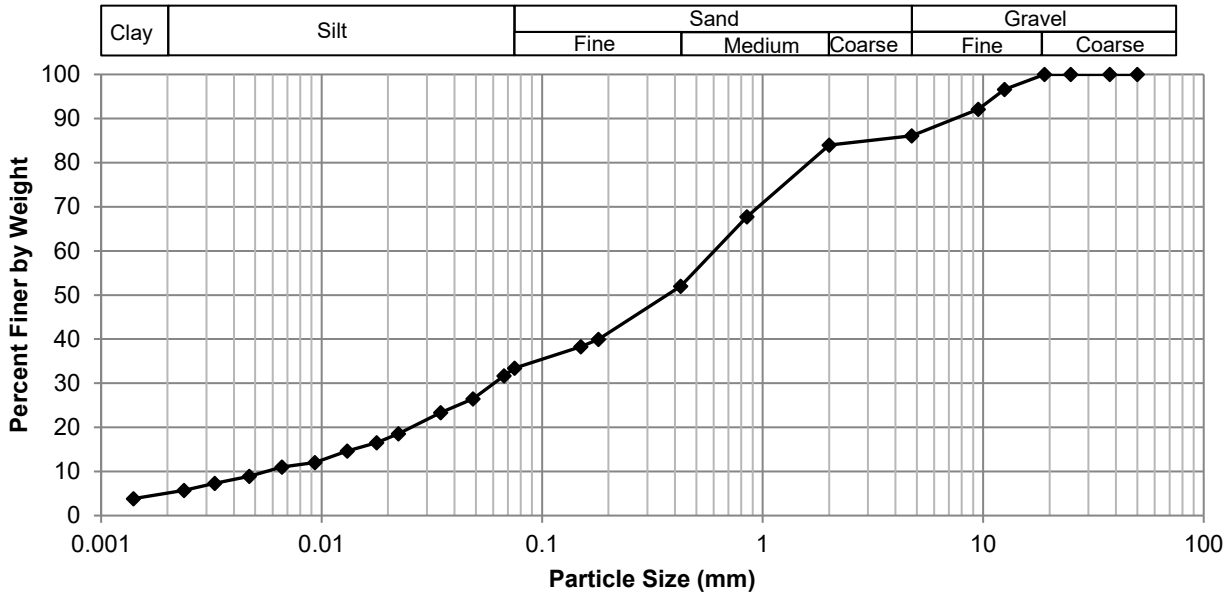
Project No. 1000-043-21
Client WSP Canada Group LTD
Project 2023 Local and Industrial Streets Package (23-RI-01) - Galt Ave



Test Hole TH22-04
Sample # G62
Depth (m) 1.1 - 1.2
Sample Date 14-Nov-22
Test Date 29-Nov-22
Technician TG

Gravel	13.9%
Sand	52.7%
Silt	28.4%
Clay	5.0%

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	86.12	0.0750	33.43
37.5	100.00	2.00	83.98	0.0673	31.72
25.0	100.00	0.850	67.70	0.0485	26.47
19.0	100.00	0.425	52.00	0.0347	23.32
12.5	96.61	0.180	39.99	0.0223	18.59
9.50	92.11	0.150	38.32	0.0178	16.49
4.75	86.12	0.075	33.43	0.0131	14.65
				0.0093	12.03
				0.0066	10.98
				0.0047	8.90
				0.0033	7.33
				0.0024	5.73
				0.0014	3.84



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Atterberg Limits
ASTM D4318-10e1

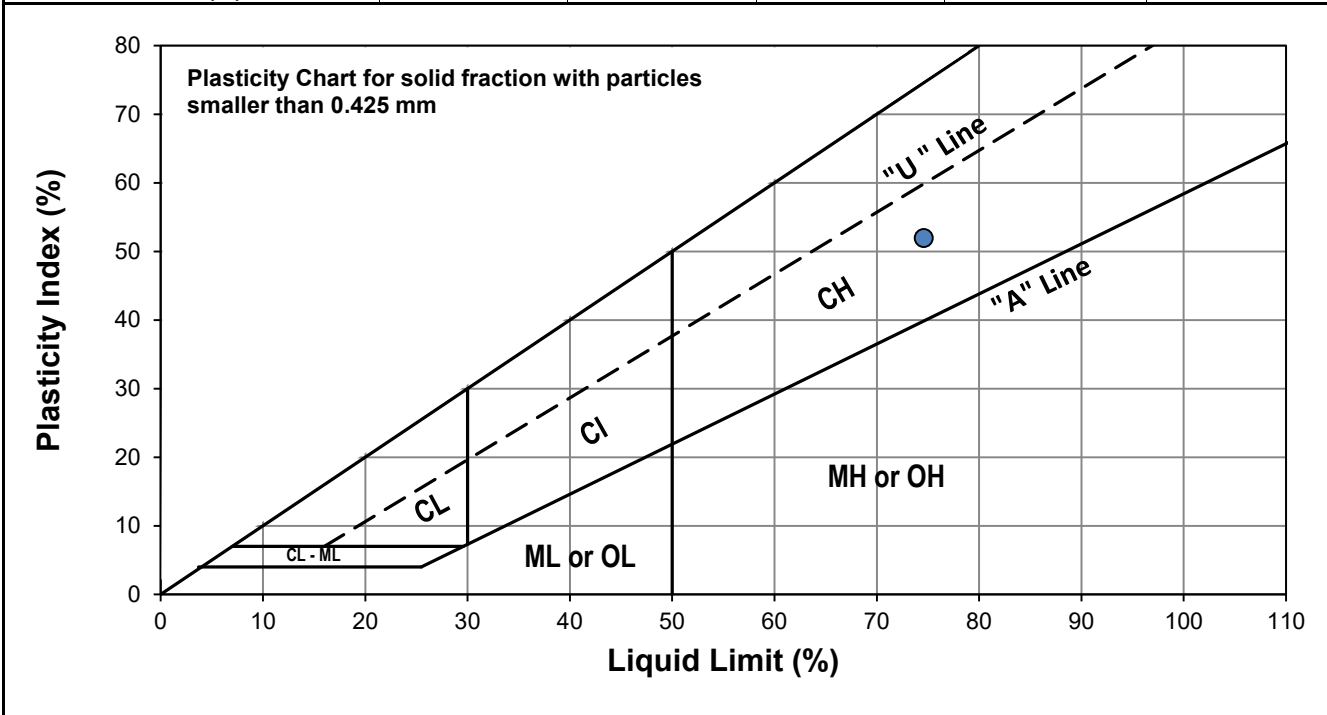
Project No. 1000-043-21
Client WSP Canada Group LTD
Project 2023 Local and Industrial Streets Package (23-RI-01) - Galt Ave
Test Hole TH22-03
Sample # G70
Depth (m) 1.1 - 1.2
Sample Date 15-Nov-22
Test Date 28-Nov-22
Technician MT



Liquid Limit	75
Plastic Limit	23
Plasticity Index	52

Liquid Limit

Trial #	1	2	3
Number of Blows (N)	16	20	34
Mass Tare (g)	14.127	14.081	13.982
Mass Wet Soil + Tare (g)	23.455	24.523	24.901
Mass Dry Soil + Tare (g)	19.314	20.003	20.348
Mass Water (g)	4.141	4.520	4.553
Mass Dry Soil (g)	5.187	5.922	6.366
Moisture Content (%)	79.834	76.326	71.521



Plastic Limit

Trial #	1	2	3	4	5
Mass Tare (g)	14.103	14.119			
Mass Wet Soil + Tare (g)	22.980	24.572			
Mass Dry Soil + Tare (g)	21.328	22.652			
Mass Water (g)	1.652	1.920			
Mass Dry Soil (g)	7.225	8.533			
Moisture Content (%)	22.865	22.501			

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



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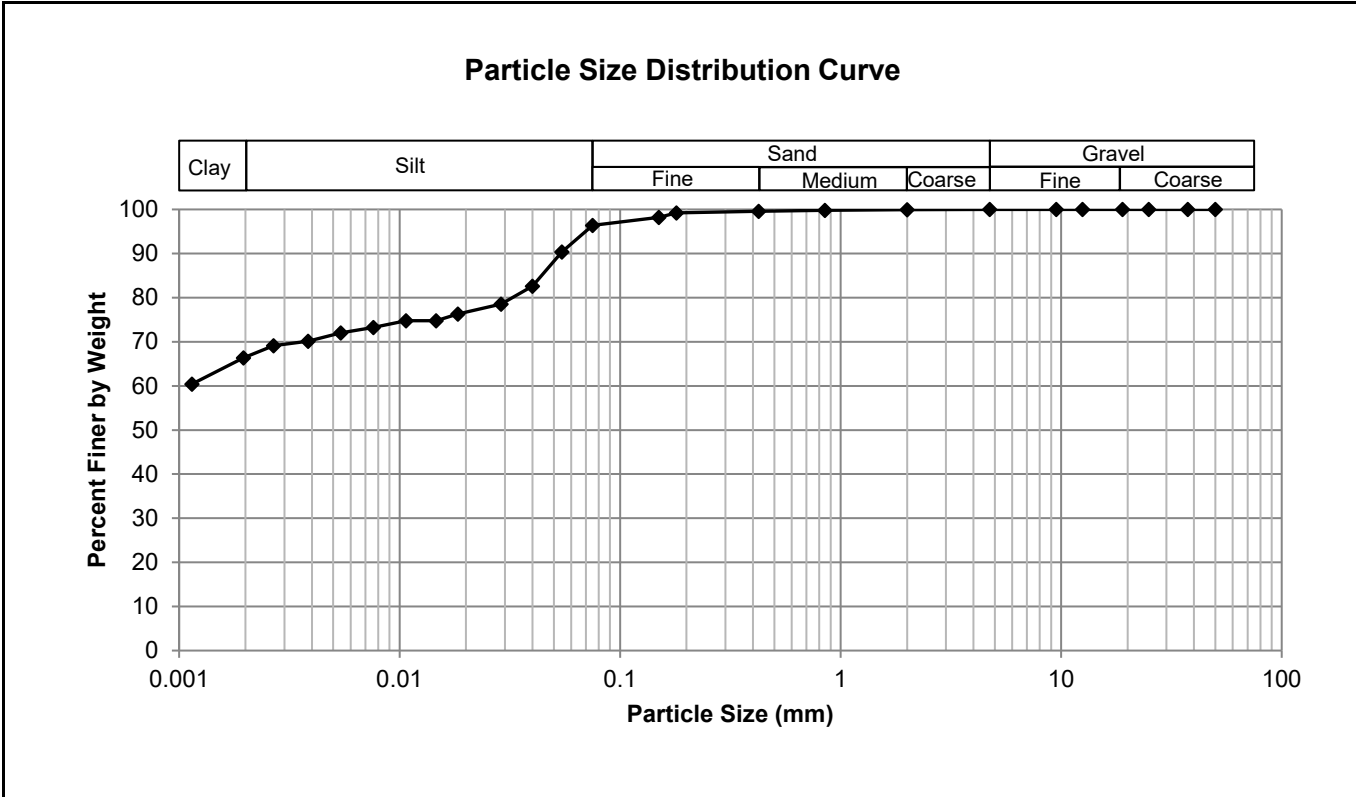
Grain Size Analysis (Hydrometer Method)
AASHTO T 88

Project No. 1000-043-21
Client WSP Canada Group LTD
Project 2023 Local and Industrial Streets Package (23-RI-01) - Galt Ave

Test Hole TH22-03
Sample # G70
Depth (m) 1.1 - 1.2
Sample Date 14-Nov-22
Test Date 29-Nov-22
Technician TG



Gravel	0.0%
Sand	3.6%
Silt	29.9%
Clay	66.5%



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	96.37
37.5	100.00	2.00	99.96	0.0545	90.39
25.0	100.00	0.850	99.83	0.0400	82.58
19.0	100.00	0.425	99.57	0.0288	78.51
12.5	100.00	0.180	99.20	0.0184	76.33
9.50	100.00	0.150	98.21	0.0146	74.76
4.75	100.00	0.075	96.37	0.0107	74.76
				0.0076	73.24
				0.0054	71.99
				0.0038	70.12
				0.0027	69.14
				0.0020	66.33
				0.0011	60.42



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Standard Proctor Compaction Test

ASTM D698-12 (2021)

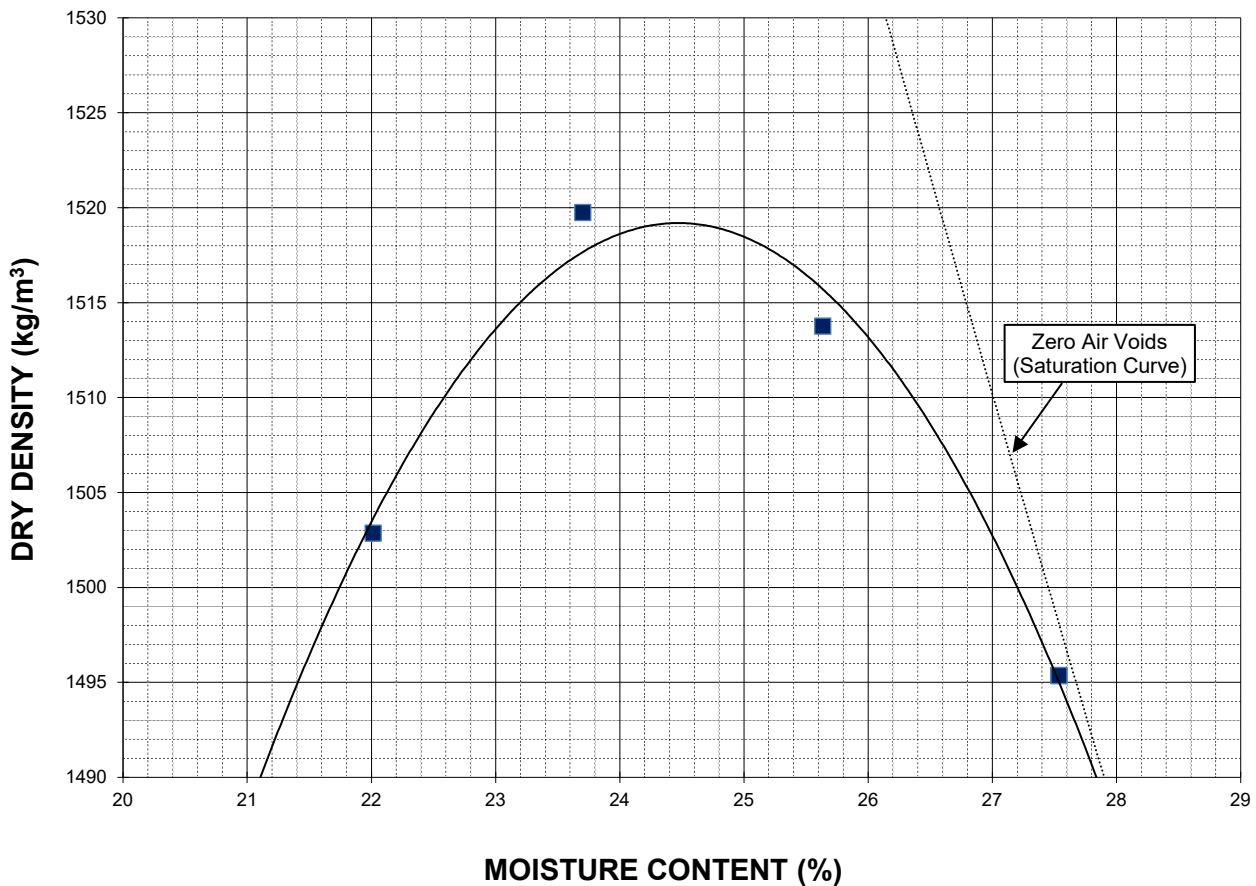


Project No. 1000-043-21
Client WSP Canada Group LTD
Project 2023 Local and Industrial Streets Package (23-RI-01)

Sample # TH22-03
Source Galt Ave.
Material Clay
Sample Date 15-Nov-22
Test Date 24-Nov-22
Technician DS

Maximum Dry Density (kg/m³)	1519
Optimum Moisture (%)	24.5

Trial Number	1	2	3	4	
Wet Density (kg/m³)	1834	1880	1902	1907	
Dry Density (kg/m³)	1503	1520	1514	1495	
Moisture Content (%)	22.0	23.7	25.6	27.5	



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



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California Bearing Ratio Test Data Sheet
ASTM D1883-16

Project No.	1000-043-21	Source	Galt Ave.
Client	WSP Canada Group Ltd.	Material	Clay
Project	2023 Local Streets Package (23-RI-01)	Sample Date	2022-11-15
Sample #	TH22-03	Test Date	2022-11-28
		Technician	DS

Proctor Results (ASTM D698)

Maximum Dry Density	1519 kg/m ³
Optimum Moisture Content	24.5 %
Material Retained on 19 mm Sieve	0.0 %

CBR Sample Compaction

Dry Density	1445 kg/m ³
Initial Moisture Content	24.9 %
Relative Density	95.1 % SPMDD

Soaking Results

Surcharge	4.54 kg
Swell	2.3 %
Moisture Content in top 25 mm	38.1 %
Immersion Period	96 h

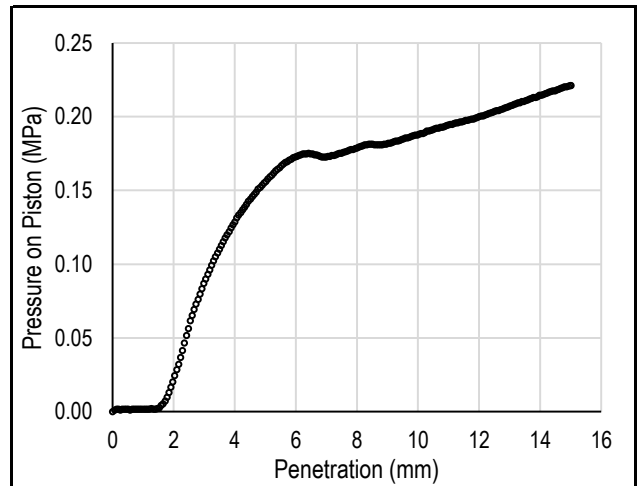
CBR Results

CBR at 2.54 mm	0.9 %
CBR at 5.08 mm	1.5 %
Zero Correction	0 mm

Test Data

Penetration (mm)	Measured Pressure (MPa)	Corrected Pressure (MPa)
0.64	0.00	0.00
1.27	0.00	0.00
1.91	0.02	0.02
2.54	0.06	0.06
3.18	0.10	0.10
3.81	0.12	0.12
4.45	0.14	0.14
5.08	0.16	0.16
7.62	0.18	0.18
10.16	0.19	0.19
12.70	0.20	0.20

Load/Penetration Curve



Comments:

Appendix C

Test Hole Logs, Summary Table & Lab Testing Results and Pavement Core Photos – MacDonald Ave

GENERAL NOTES

- 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.
- 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.
- 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		Particle Size	Material								
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)	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 cases 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	mm	Sand								
		GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW			ASTM Sieve Sizes	#10 to #4 #40 to #10 #200 to #40						
		Sands (More than half of coarse fraction is smaller than 4.75 mm)	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 borderline cases requiring use of dual symbols	mm	Coarse Medium Fine						
			GC		Clayey gravels, gravel-sand-silt mixtures	Atterberg limits above "A" line or P.I. greater than 7				$C_u = \frac{D_{60}}{D_{10}}$ greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3					
	Fine-Grained soils (More than half the material is smaller than No. 200 sieve size)	Sands with fines (Appreciable amount of fines)	SW		Well-graded sands, gravelly sands, little or no fines		Von Post Classification Limit	Strong colour or odour, and often fibrous texture	Particle Size ASTM Sieve Sizes mm > 300 75 to 300 19 to 75 4.75 to 19	Material Boulders Cobbles Gravel Coarse Fine					
			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 borderline cases requiring use of dual symbols			
			SC		Clayey sands, sand-clay mixtures						Atterberg limits above "A" line or P.I. greater than 7				
		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	Von Post Classification Limit	Strong colour or odour, and often fibrous texture	Particle Size ASTM Sieve Sizes mm > 12 in. 3 in. to 12 in. 3/4 in. to 3 in. #4 to 3/4 in.	Material Boulders Cobbles Gravel Coarse Fine
			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														
MH	Inorganic silts, micaceous or distomaceous fine sandy or silty soils, organic silts														
Silts and Clays (Liquid limit greater than 50)	CH	Inorganic clays of high plasticity, fat clays	Plasticity Chart	Von Post Classification Limit	Strong colour or odour, and often fibrous texture	Particle Size ASTM Sieve Sizes mm > 300 75 to 300 19 to 75 4.75 to 19	Material Boulders Cobbles Gravel Coarse Fine								
	OH	Organic clays of medium to high plasticity, organic silts													
Highly Organic Soils	Pt	Peat and other highly organic soils	Plasticity Chart	Von Post Classification Limit	Strong colour or odour, and often fibrous texture	Particle Size ASTM Sieve Sizes mm > 300 75 to 300 19 to 75 4.75 to 19	Material Boulders Cobbles Gravel Coarse Fine								

* 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

LEGEND OF ABBREVIATIONS AND SYMBOLS

LL - Liquid Limit (%)	▽ Water Level at Time of Drilling
PL - Plastic Limit (%)	▼ Water Level at End of Drilling
PI - Plasticity Index (%)	▽ Water Level After Drilling as Indicated on Test Hole Logs
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	

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:

<u>Descriptive Terms</u>	<u>SPT (N) (Blows/300 mm)</u>
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:

<u>Descriptive Terms</u>	<u>SPT (N) (Blows/300 mm)</u>
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:

<u>Descriptive Terms</u>	<u>Undrained Shear Strength (kPa)</u>
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

Client: WSP Canada Group Ltd. **Project Number:** 1000-043-21
Project Name: 2023 Local and Industrial Streets Renewal Package (23-RI-01) **Location:** UTM N-5529488, E-634558
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	Bulk Unit Wt (kN/m ³)						Undrained Shear Strength (kPa)					
					16	17	18	19	20	21	Test Type					
					Particle Size (%)											
					0	20	40	60	80	100						
					PL MC LL 0 20 40 60 80 100											
					0	20	40	60	80	100	0	25	50	75	100	125
0.0		ASPHALT - 90 mm thick		PC22-05												
0.0		SAND - trace silt, brown, moist, compact, no to low plasticity, poorly graded, fine sand, AASHTO: A-1-b (I)		G52	●											
0.0		CLAY - silty, trace silt inclusions (< 10 mm diam.) - blackish grey - moist, very stiff - high plasticity - AASHTO: A-7-6 (60)		G53	●									△	>>	+
0.5		- brown below 0.8 m		G54	●									△		+
1.0				G55	●									△		+
1.5				G56	●									△		+
2.0				G57	●									△		+
2.5				G58	●									△		+
3.0		- dark brown greyish below 2.9 m		G59	●									△		+

END OF TEST HOLE AT 3.2 m IN CLAY.
 1) Seepage or sloughing not observed.
 2) Test hole open to 3.2 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 #15 MacDonald Ave, 4.6 m North of South curb.
 5) The bulk sample was collected between 0.3 m and 3.2 m depth.

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

SUB-SURFACE LOG LOGS 2022-12-09 MACDONALD AVE 23-R-01.0.D JSB 1000.043.21.GPJ TREK.GDT 12/9/22



Sub-Surface Log

Client: WSP Canada Group Ltd. **Project Number:** 1000-043-21
Project Name: 2023 Local and Industrial Streets Renewal Package (23-RI-01) **Location:** UTM N-5529488, E-634582
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	Bulk Unit Wt (kN/m ³)						Undrained Shear Strength (kPa)					
					16	17	18	19	20	21	Test Type					
					Particle Size (%)											
					0	20	40	60	80	100						
					PL MC LL 0 20 40 60 80 100											
					0	20	40	60	80	100	0	25	50	75	100	125
0.0 - 0.1		ASPHALT - 130 mm thick		PC22-06												
0.1 - 0.3		SAND AND GRAVEL (FILL) - trace clay, some silt, 50 mm down crushed limestone - brown, moist, compact, no to low plasticity, angular, AASHTO: A-1-b (I)		G43	●											
0.3 - 1.5		CLAY - silty, trace silt inclusions (< 20 mm diam.) - brown - moist, stiff - high plasticity - AASHTO: A-7-6 (52)		G44		●							△	⊕		
				G45									⊕	△		
				G46		●							△	⊕		
				G47		●						⊕	△			
1.5 - 2.0		CLAY - silty, trace silt inclusions (< 10 mm diam.) - black - moist, stiff - high plasticity - AASHTO: A-7-6 (I)		G48		●							△	⊕		
2.0 - 2.5		SILT - clayey - light brown, moist, soft - low plasticity, AASHTO: A-4 (I)		G49		●						⊕	△			
				G50		●						⊕	△			
2.5 - 3.0		SILT AND CLAY - trace sand - brown - moist, soft to firm - intermediate plasticity - AASHTO: A-6 (I)		G51		●							△	⊕		

END OF TEST HOLE AT 3.2 m IN SILT AND CLAY.
 1) Seepage observed below 2.1 m depth.
 2) Sloughing not observed.
 3) Test hole open to 3.2 m depth and water level at 2.8 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 south face of #11 MacDonald Ave, 1.8 m South of North curb.
 6) The bulk sample was collected between 0.2 to 1.5 m and 1.7 to 2.1 m depth.

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

SUB-SURFACE LOG LOGS 2022-12-09 MACDONALD AVE 23-RI-01.D JSB 1000.043.21.GPJ TREK.GDT 12/9/22



2023 Local and Industrial Streets Renewal Project - 23-RI-01
Sub-Surface Investigation
MacDonald Ave - Waterfront Dr / Gomez St

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
TH22-05	UTM: 14U 5529488 N 634558 E Located in front of #15 MacDonald Ave, 4.6 m North of South curb.	Asphalt	90	Concrete	-	Sand; AASHTO: A-1-b (I)	0.1	0.3	15							
						Clay; AASHTO: A-7-6 (60)	0.3	0.5	34							
						Clay; AASHTO: A-7-6 (60)	0.8	0.9	35							
						Clay; AASHTO: A-7-6 (60)	1.1	1.2	26	58	41	1	0	22	75	53
						Clay; AASHTO: A-7-6 (60)	1.4	1.5	33							
						Clay; AASHTO: A-7-6 (60)	1.8	2.0	30							
						Clay; AASHTO: A-7-6 (60)	2.1	2.3	33							
						Clay; AASHTO: A-7-6 (60)	2.7	2.9	46							
TH22-06	UTM: 14U 5529488 N, 634582 E Located in front of #11 MacDonald Ave, 1.8 m South of North curb.	Asphalt	130	Concrete	-	Sand And Gravel (Fill); AASHTO: A-1-b (I)	0.1	0.3	13							
						Clay; AASHTO: A-7-6 (52)	0.8	0.9	30							
						Clay; AASHTO: A-7-6 (52)	1.1	1.2	35	49	47	4	0	22	70	48
						Clay; AASHTO: A-7-6 (52)	1.4	1.5	30							
						Silt; AASHTO: A-4 (I)	1.5	1.7	28							
						Clay; AASHTO: A-7-6 (I)	1.7	2.0	27							
						Silt; AASHTO: A-4 (I)	2.1	2.3	22							
						Silt; AASHTO: A-4 (I)	2.4	2.6	24							
				Silt and Clay; AASHTO: A-6 (I)	2.6	3.0	26									

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



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**Moisture Content Report
 ASTM D2216-10**

Project No. 1000-043-21
Client WSP Canada Group LTD
Project 2023 Local and Industrial Streets Package (23-RI-01) - MacDonald Ave

Sample Date 15-Nov-22
Test Date 22-Nov-22
Technician TG

Test Hole	TH22-05	TH22-05	TH22-05	TH22-05	TH22-05	TH22-05
Depth (m)	0.1 - 0.2	0.2 - 0.5	0.8 - 0.9	1.1 - 1.2	1.4 - 1.5	1.8 - 2.0
Sample #	G52	G53	G54	G55	G56	G57
Tare ID	N59	N06	H72	A39	W53	N111
Mass of tare	8.4	8.6	9.0	8.3	8.6	8.8
Mass wet + tare	256.4	279.4	316.9	426.1	251.7	285.4
Mass dry + tare	223.3	211.3	237.3	340.7	191.7	222.4
Mass water	33.1	68.1	79.6	85.4	60.0	63.0
Mass dry soil	214.9	202.7	228.3	332.4	183.1	213.6
Moisture %	15.4%	33.6%	34.9%	25.7%	32.8%	29.5%

Test Hole	TH22-05	TH22-05	TH22-06	TH22-06	TH22-06	TH22-06
Depth (m)	2.1 - 2.3	2.7 - 2.9	0.1 - 0.3	0.8 - 0.9	1.1 - 1.2	1.4 - 1.5
Sample #	G58	G59	G43	G44	G45	G46
Tare ID	E94	N76	F100	H4	P37	F26
Mass of tare	8.5	8.6	8.5	8.7	8.5	8.5
Mass wet + tare	337.7	253.9	479.9	269.5	440.9	307.3
Mass dry + tare	255.5	176.3	426.2	209.4	328.0	238.1
Mass water	82.2	77.6	53.7	60.1	112.9	69.2
Mass dry soil	247.0	167.7	417.7	200.7	319.5	229.6
Moisture %	33.3%	46.3%	12.9%	29.9%	35.3%	30.1%

Test Hole	TH22-06	TH22-06	TH22-06	TH22-06	TH22-06	
Depth (m)	1.5 - 1.7	1.7 - 2.0	2.1 - 2.3	2.4 - 2.7	2.7 - 3.0	
Sample #	G47	G48	G49	G50	G51	
Tare ID	C2	F108	W34	Z67	AB62	
Mass of tare	8.5	8.4	8.6	8.6	6.7	
Mass wet + tare	290.1	320.0	406.7	348.2	361.2	
Mass dry + tare	229.0	253.2	334.3	281.6	288.0	
Mass water	61.1	66.8	72.4	66.6	73.2	
Mass dry soil	220.5	244.8	325.7	273.0	281.3	
Moisture %	27.7%	27.3%	22.2%	24.4%	26.0%	



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Atterberg Limits
ASTM D4318-10e1

Project No. 1000-043-21
Client WSP Canada Group LTD
Project 2023 Local and Industrial Streets Package (23-RI-01) - MacDonald Ave

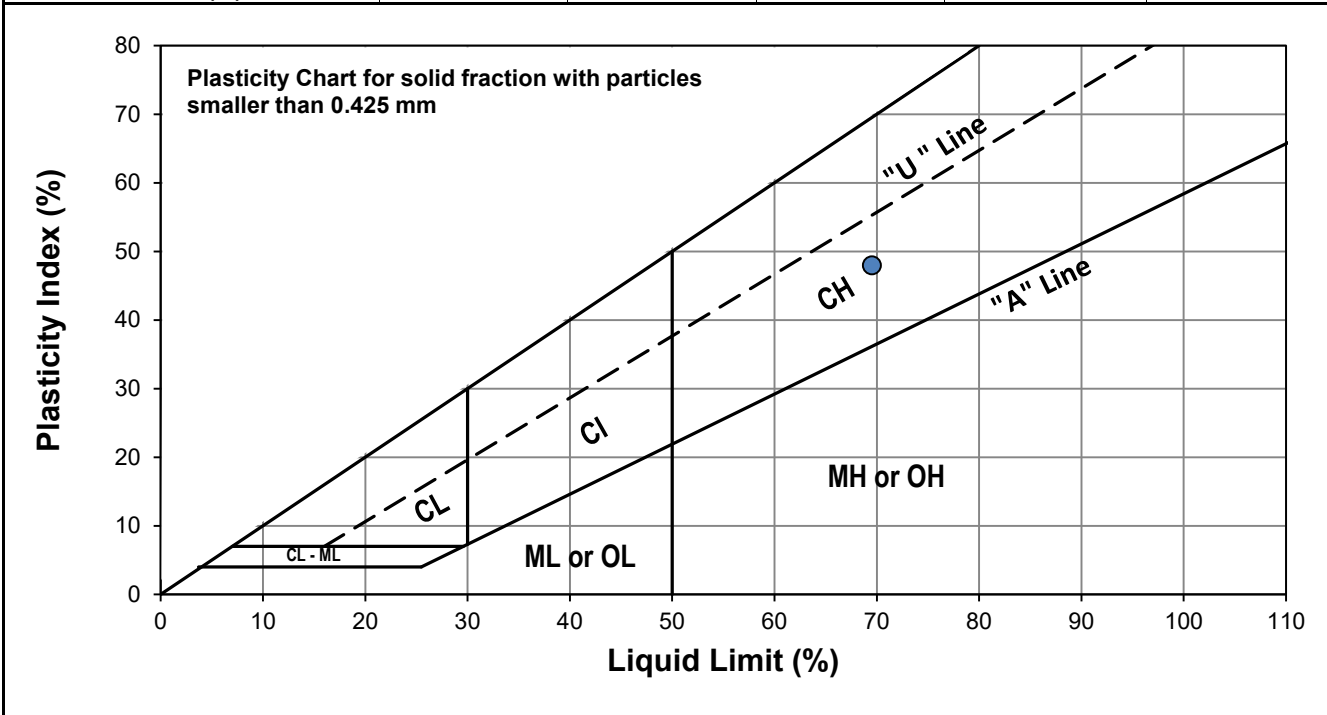
Test Hole TH22-06
Sample # G45
Depth (m) 1.1 - 1.2
Sample Date 15-Nov-22
Test Date 29-Nov-22
Technician SL



Liquid Limit	70
Plastic Limit	22
Plasticity Index	48

Liquid Limit

Trial #	1	2	3
Number of Blows (N)	16	28	34
Mass Tare (g)	14.017	14.064	14.119
Mass Wet Soil + Tare (g)	19.829	20.707	20.682
Mass Dry Soil + Tare (g)	17.395	18.001	18.028
Mass Water (g)	2.434	2.706	2.654
Mass Dry Soil (g)	3.378	3.937	3.909
Moisture Content (%)	72.054	68.733	67.895



Plastic Limit

Trial #	1	2	3	4	5
Mass Tare (g)	14.111	14.219			
Mass Wet Soil + Tare (g)	20.272	20.784			
Mass Dry Soil + Tare (g)	19.177	19.622			
Mass Water (g)	1.095	1.162			
Mass Dry Soil (g)	5.066	5.403			
Moisture Content (%)	21.615	21.507			

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



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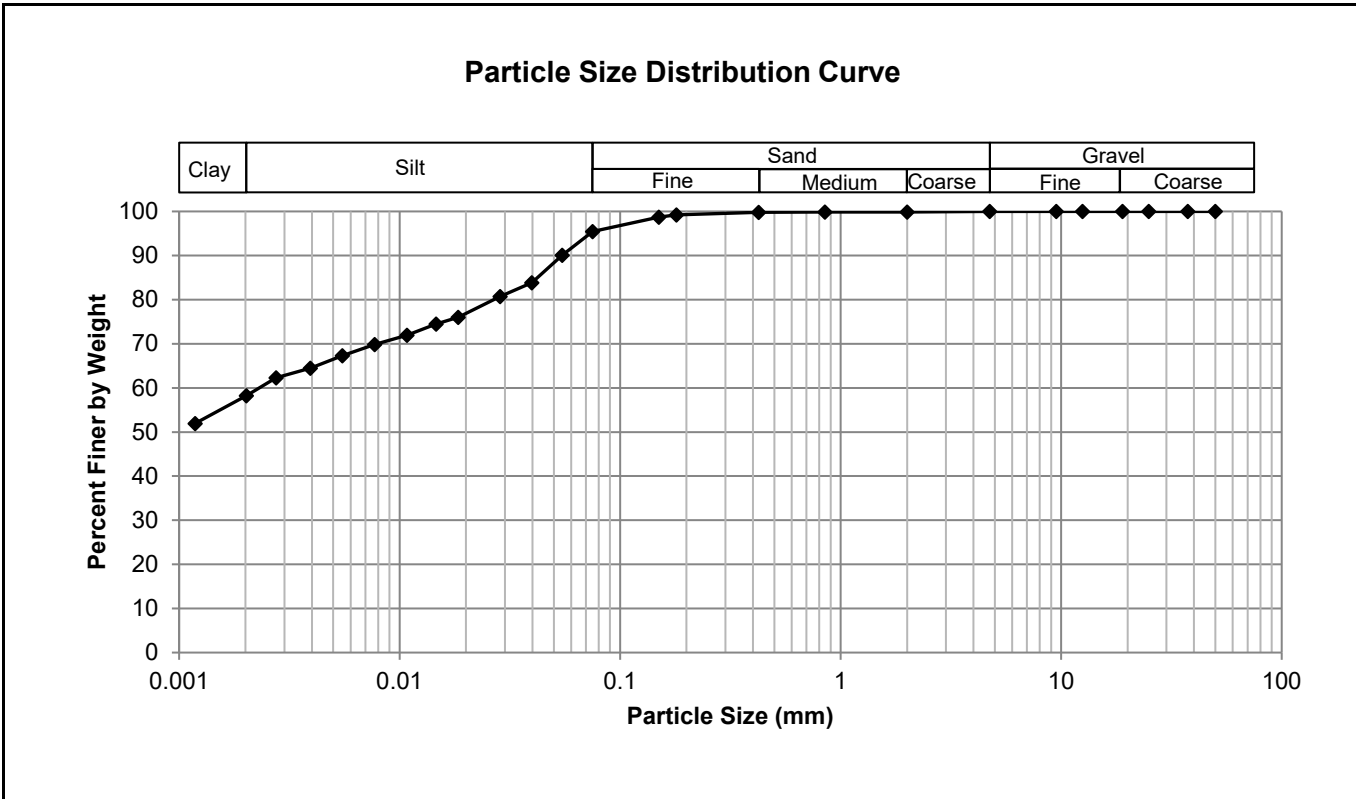
Grain Size Analysis (Hydrometer Method)
AASHTO T 88

Project No. 1000-043-21
Client WSP Canada Group LTD
Project 2023 Local and Industrial Streets Package (23-RI-01) - MacDonald Ave



Test Hole TH22-06
Sample # G45
Depth (m) 1.1 - 1.2
Sample Date 15-Nov-22
Test Date 29-Nov-22
Technician TG

Gravel	0.0%
Sand	4.5%
Silt	47.0%
Clay	48.5%



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	95.45
37.5	100.00	2.00	99.90	0.0546	90.07
25.0	100.00	0.850	99.87	0.0398	83.83
19.0	100.00	0.425	99.79	0.0285	80.70
12.5	100.00	0.180	99.20	0.0184	76.02
9.50	100.00	0.150	98.72	0.0147	74.46
4.75	100.00	0.075	95.45	0.0108	71.96
				0.0077	69.81
				0.0055	67.31
				0.0039	64.50
				0.0028	62.28
				0.0020	58.22
				0.0012	51.95



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ASTM D4318-10e1

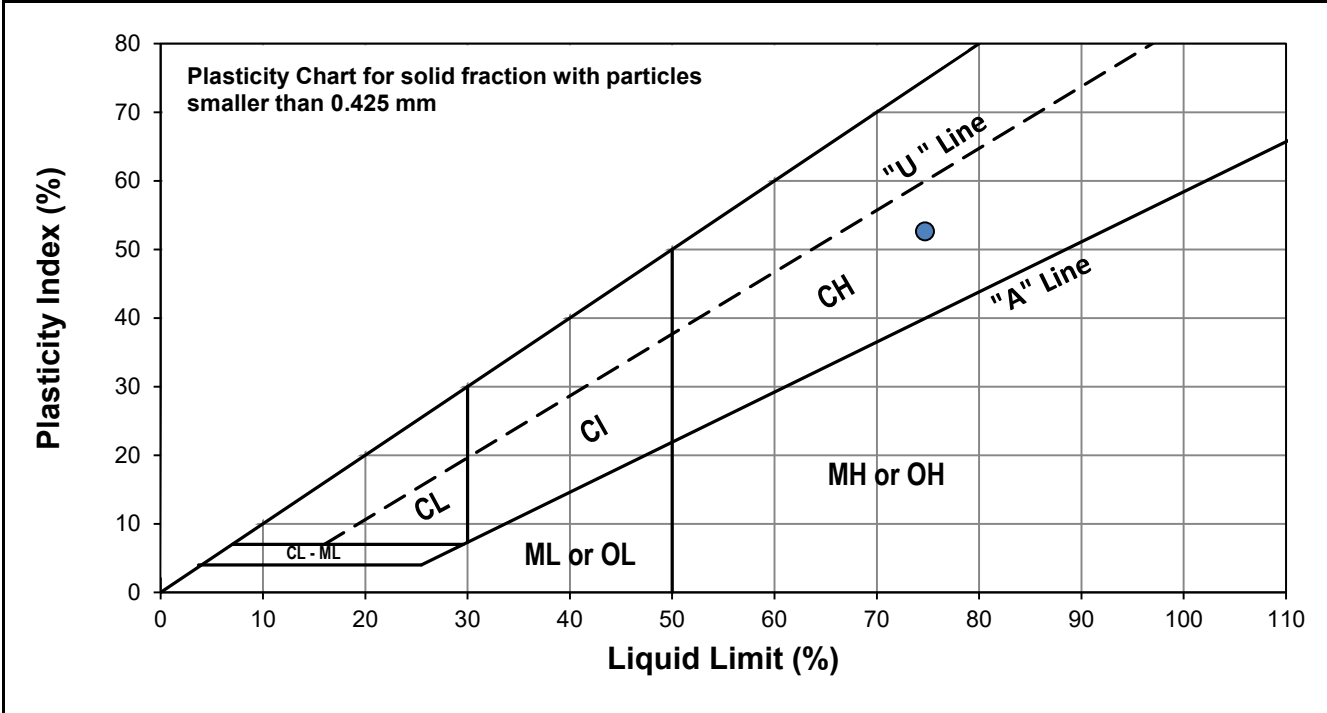
Project No. 1000-043-21
Client WSP Canada Group LTD
Project 2023 Local and Industrial Streets Package (23-RI-01) - MacDonald Ave
Test Hole TH22-05
Sample # G55
Depth (m) 1.1 - 1.2
Sample Date 15-Nov-22
Test Date 29-Nov-22
Technician MT



Liquid Limit	75
Plastic Limit	22
Plasticity Index	53

Liquid Limit

Trial #	1	2	3
Number of Blows (N)	22	28	33
Mass Tare (g)	13.975	13.927	14.033
Mass Wet Soil + Tare (g)	20.903	19.915	21.208
Mass Dry Soil + Tare (g)	17.900	17.389	18.225
Mass Water (g)	3.003	2.526	2.983
Mass Dry Soil (g)	3.925	3.462	4.192
Moisture Content (%)	76.510	72.964	71.159



Plastic Limit

Trial #	1	2	3	4	5
Mass Tare (g)	14.111	14.093			
Mass Wet Soil + Tare (g)	24.007	24.681			
Mass Dry Soil + Tare (g)	22.222	22.760			
Mass Water (g)	1.785	1.921			
Mass Dry Soil (g)	8.111	8.667			
Moisture Content (%)	22.007	22.165			

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



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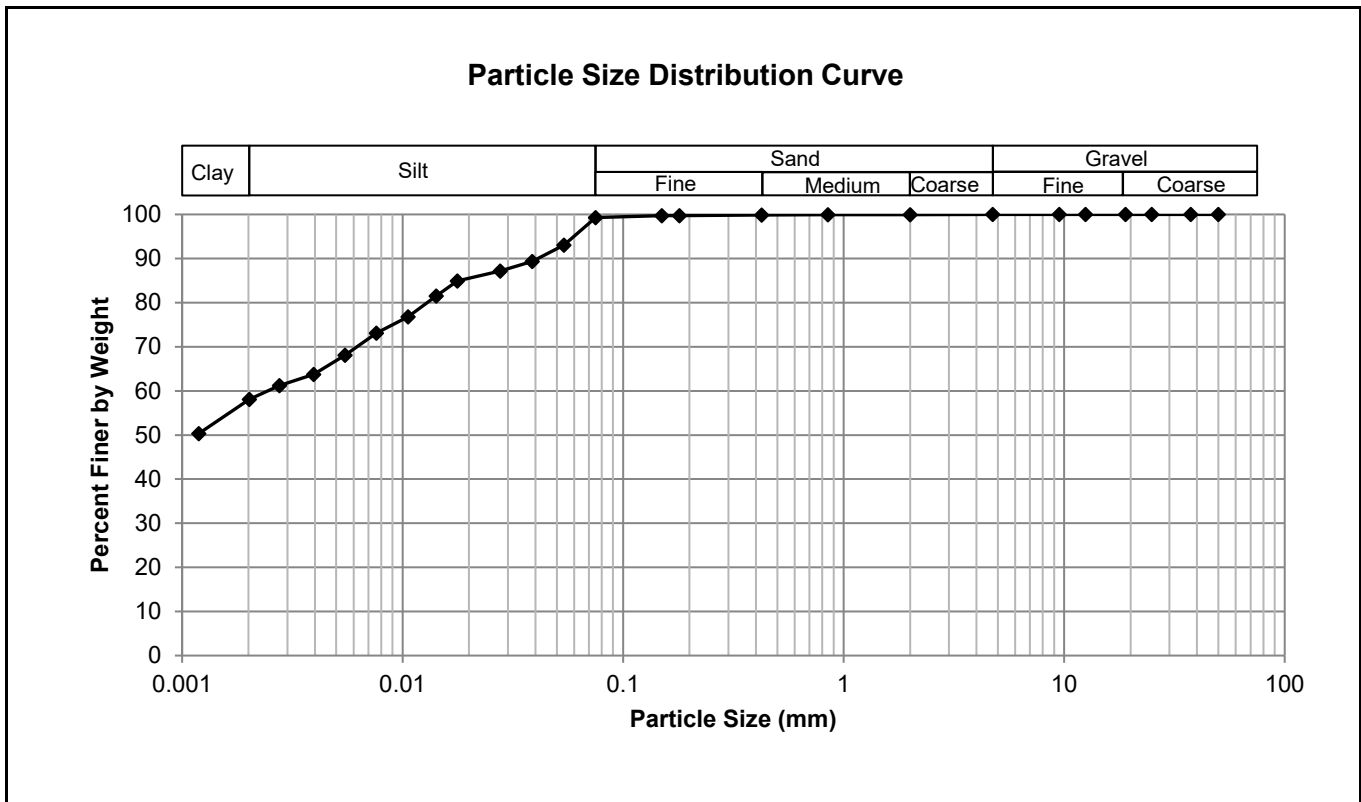
Grain Size Analysis (Hydrometer Method)
AASHTO T 88

Project No. 1000-043-21
Client WSP Canada Group LTD
Project 2023 Local and Industrial Streets Package (23-RI-01) - MacDonald Ave

Test Hole TH22-05
Sample # G55
Depth (m) 1.1 - 1.2
Sample Date 15-Nov-22
Test Date 29-Nov-22
Technician TG



Gravel	0.0%
Sand	0.7%
Silt	41.4%
Clay	57.9%



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	99.32
37.5	100.00	2.00	99.97	0.0538	93.08
25.0	100.00	0.850	99.95	0.0388	89.33
19.0	100.00	0.425	99.89	0.0277	87.14
12.5	100.00	0.180	99.76	0.0177	84.96
9.50	100.00	0.150	99.73	0.0142	81.52
4.75	100.00	0.075	99.32	0.0106	76.83
				0.0076	73.13
				0.0055	68.13
				0.0039	63.75
				0.0028	61.20
				0.0020	58.07
				0.0012	50.31



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Standard Proctor Compaction Test ASTM D698-12 (2021)

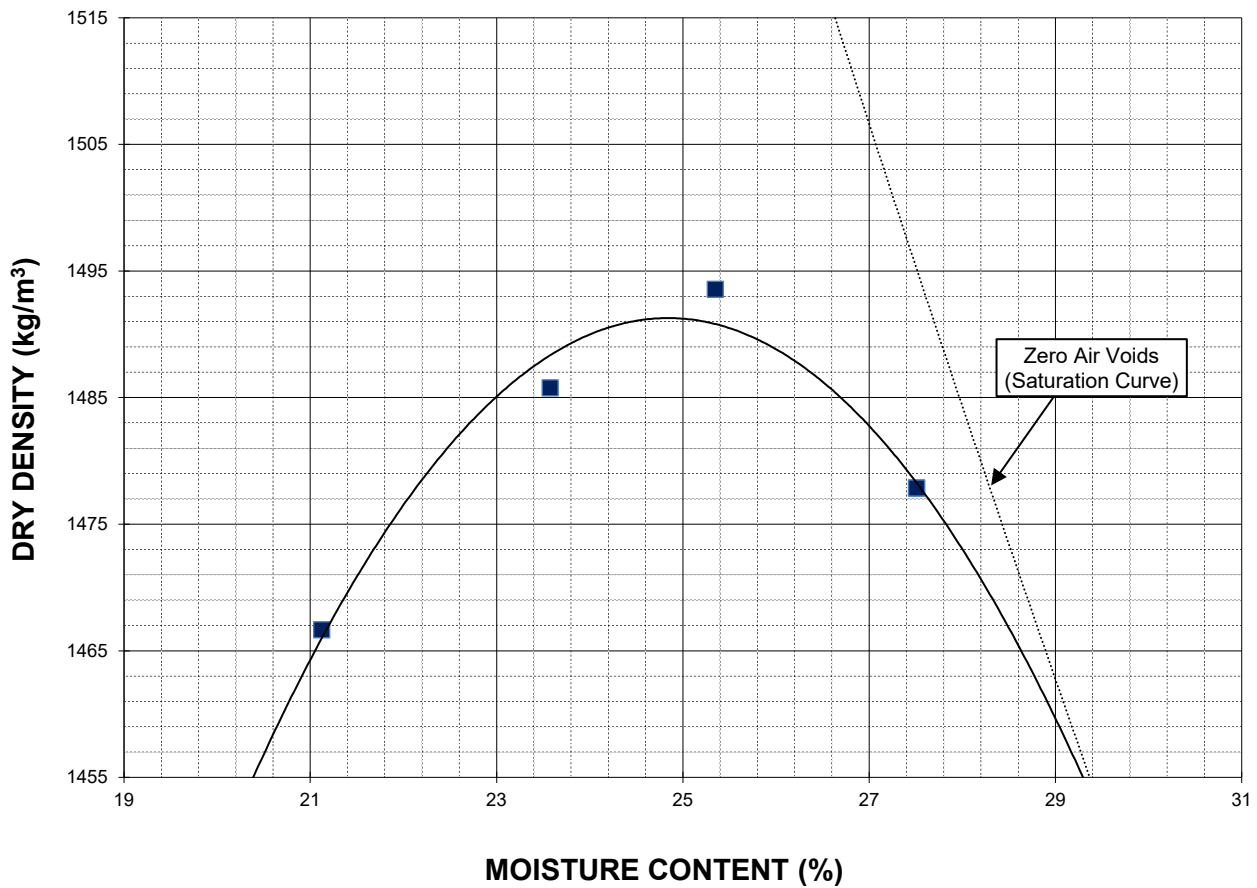


Project No. 1000-043-21
Client WSP Canada Group LTD
Project 2023 Local and Industrial Streets Package (23-RI-01)

Sample # TH22-05
Source MacDonald Ave.
Material Clay
Sample Date 15-Nov-22
Test Date 24-Nov-22
Technician DS

Maximum Dry Density (kg/m³)	1491
Optimum Moisture (%)	24.8

Trial Number	1	2	3	4	
Wet Density (kg/m³)	1776	1836	1872	1884	
Dry Density (kg/m³)	1467	1486	1494	1478	
Moisture Content (%)	21.1	23.6	25.3	27.5	



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

Appendix D

Summary Table and Pavement Core Photos – Alexander Ave



2023 Local and Industrial Streets Renewal Package - 23-RI-01

Alexander Ave - Marth St / Lily St

Pavement Core No.	Pavement Core Location	Pavement Surface		Pavement Structure Material		
		Type	Thickness (mm)	Type	Thickness (mm)	Corrected Compressive Strength (Mpa)
PC22-07	UTM : 5529314 m N, 633918 m E; Located in front of north entrance of #145 Pacific Ave, 1.5 m South of North Curb.	Asphalt	70	Concrete	220	-
PC22-08	UTM : 5529310 m N, 633909 m E; Located in front of north entrance of #145 Pacific Ave, 2.3 m North of South Curb.	Asphalt	80	Concrete	-	-
PC22-09	UTM : 5529295 m N, 633954 m E; Located in front of #155 Alexander Ave, 1.4 m South of North Curb.	Asphalt	-	Concrete	225	69.81



Photo 1: Pavement Core Sample PC-07



Photo 2: Pavement Core Sample PC-08



Photo 3: Pavement Core Sample PC-09

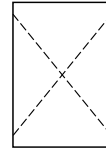
Project No. 1000-043-21
Project 2023 Local Streets Package - 23-R1-01
Client WSP Group Canada Inc.

Date December 7, 2022
Technician KM

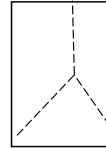
Core Location	Core ID	Date Received	Date of Break	Age at Break	Diam. (mm)	Length (mm)	Moisture Conditioning	Compressive Strength (MPa)		Break Type	Correction Factors*				
								Uncorrected f_{conc}	Corrected* f_c		$F_{l/d}$	F_{dia}	F_{mc}	F_D	F_{reinf}
Alexander Avenue	PC-09	Nov.9th/22	2022-12-07	-	146	220	Soaked 48 h	55.32	69.81	1	0.9773	0.9801	1.0900	1.0600	1.1403

Comments

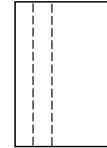
*Correction factors $F_{l/d}$, F_{dia} , F_{mc} , and F_D calculated as per ACI 214.4R-03, and correction factor F_{reinf} calculated as per Khoury et al. (2014): $f_c = f_{conc} F_{l/d} F_{dia} F_{mc} F_D F_{reinf}$



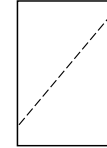
Type 1



Type 2



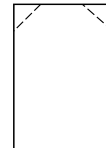
Type 3



Type 4



Type 5



Type 6

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

Signature: Angela Fidler-Kliwer

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 interpreta-

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

tion 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:

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

cc. 12 or cc. 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 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:

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

- 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

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

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.

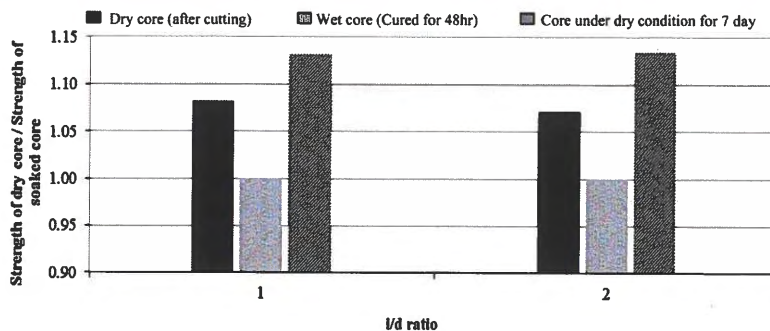


Figure 20 Effect of core moisture condition on core strength for different aspect ratios (l/d).

Appendix E

Summary Table and Pavement Core Photos – McDermot Ave



2023 Local and Industrial Streets Renewal Package - 23-RI-01

McDermot Ave - Myrtle St / McPhillips St

Pavement Core No.	Pavement Core Location	Pavement Surface		Pavement Structure Material		
		Type	Thickness (mm)	Type	Thickness (mm)	Corrected Compressive Strength (Mpa)
PC22-10	UTM : 5530064 m N, 631055 m E; Located in front of #1139 McDermot Ave, 3.8 m South of North Curb.	Asphalt	-	Concrete	220	67.6
PC22-11	UTM : 5530008 m N, 631160 m E; Located in front of #1-1090 McDermot Ave, 2.9 m North of South Curb.	Asphalt	-	Concrete	250	-
PC22-12	UTM : 5529968 m N, 631260 m E; Located in front of South wall of #100 McPhillips St, 3.0 m South of North edge of road.	Asphalt	-	Concrete	225	-



Photo 1: Pavement Core Sample PC-10



Photo 2: Pavement Core Sample PC-11



Photo 3: Pavement Core Sample PC-12

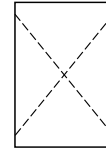
Project No. 1000-043-21
Project 2023 Local Streets Package - 23-R1-01
Client WSP Group Canada Inc.

Date December 7, 2022
Technician KM

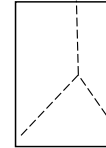
Core Location	Core ID	Date Received	Date of Break	Age at Break	Diam. (mm)	Length (mm)	Moisture Conditioning	Compressive Strength (MPa)		Break Type	Correction Factors*				
								Uncorrected f_{conc}	Corrected* f_c		$F_{l/d}$	F_{dia}	F_{mc}	F_D	F_{reinf}
McDermot Avenue	PC-10	2022-11-14	2022-12-07	-	146	204	Soaked 48 h	61.72	67.60	1	0.9671	0.9801	1.0900	1.0600	1.0000

Comments

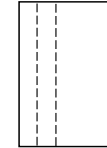
*Correction factors $F_{l/d}$, F_{dia} , F_{mc} , and F_D calculated as per ACI 214.4R-03, and correction factor F_{reinf} calculated as per Khoury et al. (2014): $f_c = f_{conc} F_{l/d} F_{dia} F_{mc} F_D F_{reinf}$



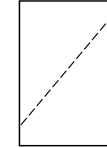
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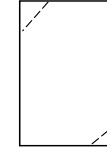
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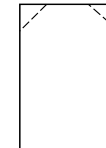
Type 3



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 interpreta-

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

tion 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:

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

cc. 12 or cc. 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 3 Strength correction factors according to ACI 214.4R-03.

List	Factors	Mean values
(1) ^b	$F_{l/d}$: l/d ratio	
	As-received	$1 - \{0.130 - \alpha f_{core}\} (2 - \frac{1}{d})^2$
	Soaked 48 h	$1 - \{0.117 - \alpha f_{core}\} (2 - \frac{1}{d})^2$
	Air dried ^a	$1 - \{0.144 - \alpha f_{core}\} (2 - \frac{1}{d})^2$
(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:

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

- 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

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

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.

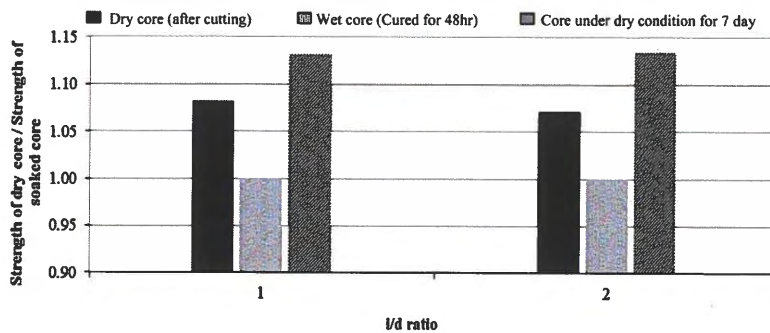


Figure 20 Effect of core moisture condition on core strength for different aspect ratios (l/d).

Appendix F

Summary Table and Pavement Core Photos – Argyle St



2023 Local and Industrial Streets Renewal Package - 23-RI-01

Argyle St - George Av / Disraeli Fr

Pavement Core No.	Pavement Core Location	Pavement Surface		Pavement Structure Material		
		Type	Thickness (mm)	Type	Thickness (mm)	Corrected Compressive Strength (Mpa)
PC22-13	UTM : 5529355 m N, 634314 m E; Located in front of West entrance of #500 Waterfront Dr, 2.0 m West of East Curb.	Asphalt	-	Concrete	230	61.89
PC22-14	UTM : 5529411 m N, 634338 m E; Located in front of #19 Argyle St, 1.2 East of West Curb.	Asphalt	-	Concrete	230	63.33



Photo 1: Pavement Core Sample PC-13

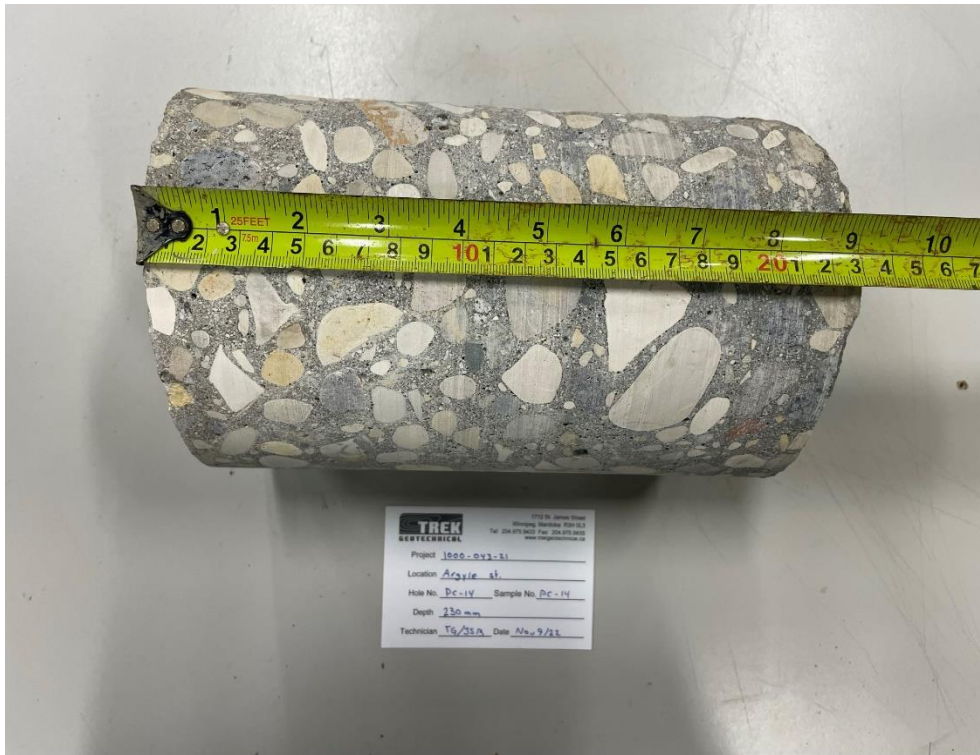


Photo 2: Pavement Core Sample PC-14

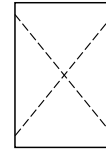
Project No. 1000-043-21
Project 2023 Local Streets Package - 23-R1-01
Client WSP Group Canada Inc.

Date December 7, 2022
Technician KM

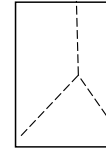
Core Location	Core ID	Date Received	Date of Break	Age at Break	Diam. (mm)	Length (mm)	Moisture Conditioning	Compressive Strength (MPa)		Break Type	Correction Factors*				
								Uncorrected f_{conc}	Corrected* f_c		$F_{l/d}$	F_{dia}	F_{mc}	F_D	F_{reinf}
Argyle Street	PC-13	2022-11-09	2022-12-07	-	146	222	Soaked 48 h	55.85	61.89	1	0.9786	0.9801	1.0900	1.0600	1.0000
Argyle Street	PC-14	2022-11-09	2022-12-07	-	146	217	Soaked 48 h	52.75	63.33	1	0.9751	0.9801	1.0900	1.0600	1.0872

Comments

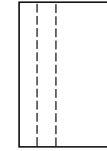
*Correction factors $F_{l/d}$, F_{dia} , F_{mc} , and F_D calculated as per ACI 214.4R-03, and correction factor F_{reinf} calculated as per Khoury et al. (2014): $f_c = f_{conc} F_{l/d} F_{dia} F_{mc} F_D F_{reinf}$



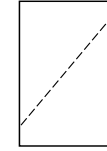
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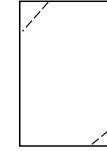
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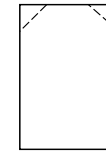
Type 3



Type 4



Type 5



Type 6

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

Signature: Angela Fidler-Kliwer

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		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 $(\sum \Phi_r * d)$.

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	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

tion 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:

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cc. 12 or cc. 15

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	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.
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- ◆ 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:

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

- 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

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

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.

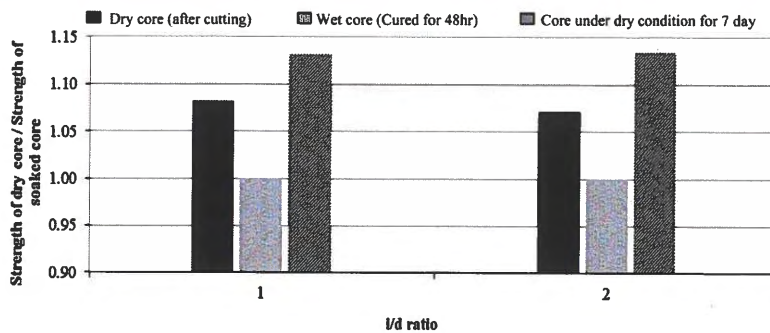


Figure 20 Effect of core moisture condition on core strength for different aspect ratios (l/d).

Appendix H

Summary Table and Pavement Core Photos – Bentall St



2023 Local and Industrial Streets Renewal Package - 23-RI-01
Bentall St - Mountain Ave / Redwood Ave

Pavement Core No.	Pavement Core Location	Pavement Surface		Pavement Structure Material		
		Type	Thickness (mm)	Type	Thickness (mm)	Corrected Compressive Strength (Mpa)
PC22-18	UTM : 5532770 m N, 630721 m E; Located in front of #21 Bentall Ave, 1.2 m West of East Curb.	Asphalt	-	Concrete	220	63.80
PC22-19	UTM : 5532899 m N, 630774 m E; Located in front of East side of #1410 Mountain Ave, 1.5 m East of West Curb.	Asphalt	-	Concrete	220	63.14



Photo 1: Pavement Core Sample PC-18



Photo 2: Pavement Core Sample PC-19

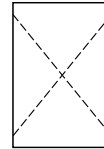
Project No. 1000-043-21
Project 2023 Local Streets Package - 23-R1-01
Client WSP Group Canada Inc.

Date December 7, 2022
Technician KM

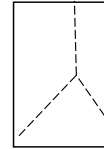
Core Location	Core ID	Date Received	Date of Break	Age at Break	Diam. (mm)	Length (mm)	Moisture Conditioning	Compressive Strength (MPa)		Break Type	Correction Factors*				
								Uncorrected f_{conc}	Corrected* f_c		$F_{l/d}$	F_{dia}	F_{mc}	F_D	F_{reinf}
Bentall Street	PC-18	2022-11-07	2022-12-07	-	146	209	Soaked 48 h	58.07	63.80	1	0.9703	0.9801	1.0900	1.0600	1.0000
Bentall Street	PC-19	2022-11-07	2022-12-07	-	146	212	Soaked 48 h	57.34	63.14	1	0.9723	0.9801	1.0900	1.0600	1.0000

Comments

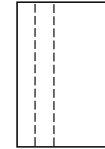
*Correction factors $F_{l/d}$, F_{dia} , F_{mc} , and F_D calculated as per ACI 214.4R-03, and correction factor F_{reinf} calculated as per Khoury et al. (2014): $f_c = f_{conc} F_{l/d} F_{dia} F_{mc} F_D F_{reinf}$



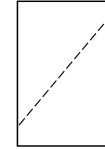
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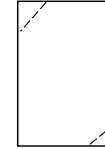
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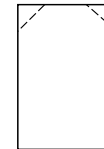
Type 3



Type 4



Type 5



Type 6

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

Signature: Angela Fidler-Kliwer

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 interpreta-

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

tion 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:

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

cc. 12 or cc. 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 3 Strength correction factors according to ACI 214.4R-03.

List	Factors	Mean values
(1) ^b	$F_{l/d}$: l/d ratio	
	As-received	$1 - \{0.130 - \alpha f_{core}\} (2 - \frac{1}{d})^2$
	Soaked 48 h	$1 - \{0.117 - \alpha f_{core}\} (2 - \frac{1}{d})^2$
	Air dried ^a	$1 - \{0.144 - \alpha f_{core}\} (2 - \frac{1}{d})^2$
(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:

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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).

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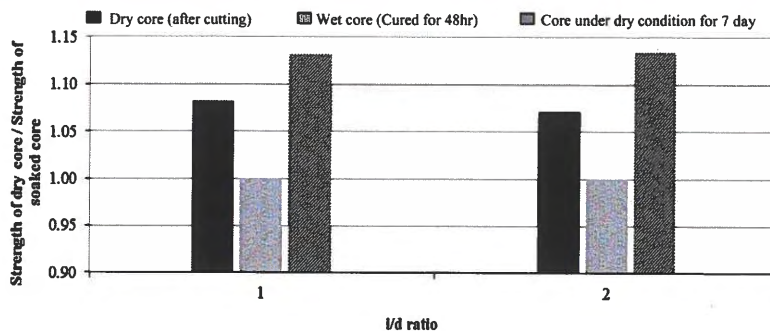


Figure 20 Effect of core moisture condition on core strength for different aspect ratios (l/d).

Appendix I

Summary Table and Pavement Core Photos – Wyatt Rd



2023 Local and Industrial Streets Renewal Package - 23-RI-01
Wyatt Rd - Filkow By / Inkster Blvd and Mandalay Dr / Filkow By

Pavement Core No.	Pavement Core Location	Pavement Surface		Pavement Structure Material		
		Type	Thickness (mm)	Type	Thickness (mm)	Corrected Compressive Strength (Mpa)
PC22-20	UTM : 5534259 m N, 630120 m E; Located 8 m south of the South-East entrance of #1771 Inkster Blvd, 2.0 m East of West Curb.	Asphalt	-	Concrete	200	64.22
PC22-21	UTM : 5534403 m N, 630092 m E; Located in front of #1725 Inkster Blvd, 1.2 m West of East Curb.	Asphalt	100	Concrete	140	-
PC22-22	UTM : 5534435 m N, 630302 m E; Located in front of #174 Wyatt Rd, 2.0 m South of North Curb.	Asphalt	-	Concrete	195	63.34



Photo 1: Pavement Core Sample PC-20



Photo 2: Pavement Core Sample PC-21



Photo 3: Pavement Core Sample PC-22

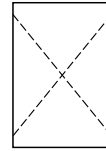
Project No. 1000-043-21
Project 2023 Local Streets Package - 23-R1-01
Client WSP Group Canada Inc.

Date December 7, 2022
Technician KM

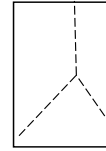
Core Location	Core ID	Date Received	Date of Break	Age at Break	Diam. (mm)	Length (mm)	Moisture Conditioning	Compressive Strength (MPa)		Break Type	Correction Factors*				
								Uncorrected f_{conc}	Corrected* f_c		$F_{l/d}$	F_{dia}	F_{mc}	F_D	F_{reinf}
Wyatt Street	PC-20	2022-11-07	2022-12-07	-	145	186	Soaked 48 h	55.23	64.22	1	0.9520	0.9802	1.0900	1.0600	1.0785
Wyatt Street	PC-22	2022-11-07	2022-12-07	-	146	185	Soaked 48 h	58.83	63.34	1	0.9507	0.9801	1.0900	1.0600	1.0000

Comments

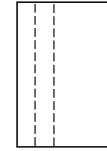
*Correction factors $F_{l/d}$, F_{dia} , F_{mc} , and F_D calculated as per ACI 214.4R-03, and correction factor F_{reinf} calculated as per Khoury et al. (2014): $f_c = f_{conc} F_{l/d} F_{dia} F_{mc} F_D F_{reinf}$



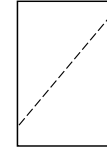
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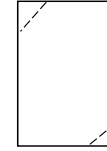
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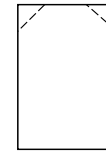
Type 3



Type 4



Type 5



Type 6

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

Signature: *Angela Fidler-Kliwer*

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		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 $(\sum \Phi_r * d)$.

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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].

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Starting from Year 2003, significant changes have been made to the relevant ACI Code provisions regarding the interpreta-

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	Specimen length-to-diameter ratio, l/d			
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$$f_c = F_{l/d} \cdot F_{dia} \cdot F_{mc} \cdot F_D \cdot f_{core} \cdot \text{Front} \tag{5}$$

cc. 12 or cc. 15

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	Air dried ^a	$1 - \{0.144 - \alpha f_{core}\} (2 - \frac{1}{d})^2$
(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:

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

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multiple bars

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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.

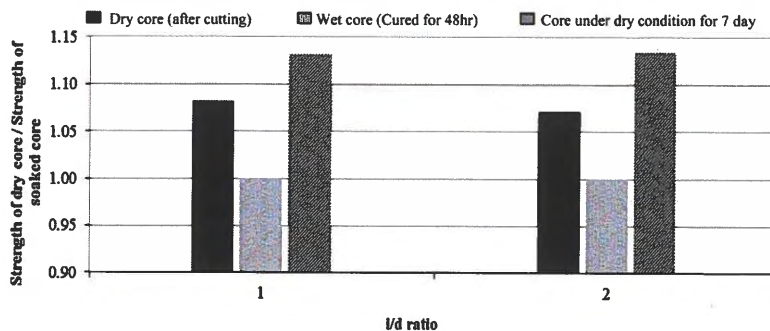


Figure 20 Effect of core moisture condition on core strength for different aspect ratios (l/d).

Appendix J

Summary Table and Pavement Core Photos – Pacific Ave



2023 Local and Industrial Streets Renewal Package - 23-RI-01
Pacific Ave - McPhillips St / Xante St and Xante St/ Arlington St

Pavement Core No.	Pavement Core Location	Pavement Surface		Pavement Structure Material		
		Type	Thickness (mm)	Type	Thickness (mm)	Corrected Compressive Strength (Mpa)
PC22-23	UTM : 5530380 m N, 631479 m E; Located in front of #1021 Pacific Ave, 2.1 m South of North Curb.	Asphalt	-	Concrete	180	66.89
PC22-24	UTM : 5530289 m N, 631667 m E; Located in front of #965 Pacific Ave, 1.8 m South of North Curb.	Asphalt	65	Concrete	180	-
PC22-25	UTM : 5530240 m N, 631769 m E; Located in front of South face of #1070 Arlington St, 1.5 m North of South Curb.	Asphalt	55	Concrete	225	-



Photo 1: Pavement Core Sample PC-23



Photo 2: Pavement Core Sample PC-24



Photo 3: Pavement Core Sample PC-25

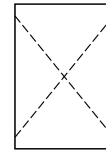
Project No. 1000-043-21
Project 2023 Local Streets Package - 23-R1-01
Client WSP Group Canada Inc.

Date December 7, 2022
Technician KM

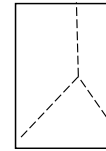
Core Location	Core ID	Date Received	Date of Break	Age at Break	Diam. (mm)	Length (mm)	Moisture Conditioning	Compressive Strength (MPa)		Break Type	Correction Factors*				
								Uncorrected f_{conc}	Corrected* f_c		$F_{l/d}$	F_{dia}	F_{mc}	F_D	F_{reinf}
Pacific Avenue	PC-23	2022-11-14	2022-12-07	-	146	171	Soaked 48 h	57.06	66.89	1	0.9365	0.9801	1.0900	1.0600	1.1054

Comments

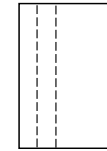
*Correction factors $F_{l/d}$, F_{dia} , F_{mc} , and F_D calculated as per ACI 214.4R-03, and correction factor F_{reinf} calculated as per Khoury et al. (2014): $f_c = f_{conc} F_{l/d} F_{dia} F_{mc} F_D F_{reinf}$



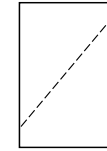
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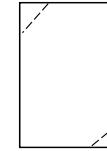
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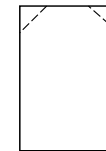
Type 3



Type 4



Type 5



Type 6

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

Signature: Angela Fidler-Kliwer

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 interpreta-

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

tion 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:

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

cc. 12 or cc. 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 3 Strength correction factors according to ACI 214.4R-03.

List	Factors	Mean values
(1) ^b	$F_{l/d}$: l/d ratio	
	As-received	$1 - \{0.130 - \alpha f_{core}\} (2 - \frac{1}{d})^2$
	Soaked 48 h	$1 - \{0.117 - \alpha f_{core}\} (2 - \frac{1}{d})^2$
	Air dried ^a	$1 - \{0.144 - \alpha f_{core}\} (2 - \frac{1}{d})^2$
(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:

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

- 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

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

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.

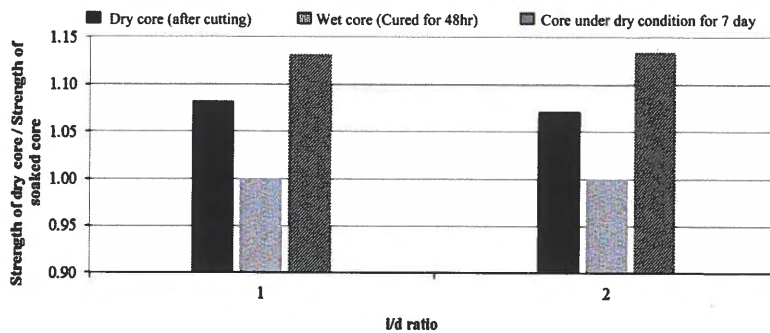


Figure 20 Effect of core moisture condition on core strength for different aspect ratios (l/d).

Appendix K

Summary Table and Pavement Core Photos – Bunting St



2023 Local and Industrial Streets Renewal Package - 23-RI-01

Bunting St - Inkster Blvd / Church Ave

Pavement Core No.	Pavement Core Location	Pavement Surface		Pavement Structure Material		
		Type	Thickness (mm)	Type	Thickness (mm)	Corrected Compressive Strength (Mpa)
PC22-26	UTM : 5533274 m N, 631130 m E; Located in front of #12 Bunting St, 1.8 m West of East Curb.	Asphalt	-	Concrete	180	63.39
PC22-27	UTM : 5533386 m N, 631182 m E; Located in front of #34 Bunting St, 2.2 m West of East Curb.	Asphalt	65	Concrete	180	-
PC22-28	UTM : 5533576 m N, 631263 m E; Located in front of #89 Bunting St, 1.5 m East of West Curb.	Asphalt	55	Concrete	225	66.10



Photo 1: Pavement Core Sample PC-26



Photo 2: Pavement Core Sample PC-27



Photo 3: Pavement Core Sample PC-28

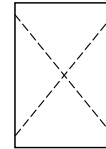
Project No. 1000-043-21
Project 2023 Local Streets Package - 23-R1-01
Client WSP Group Canada Inc.

Date December 7, 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}
Bunting Street	PC-26	2022-11-07	2022-12-07	-	145	205	Soaked 48 h	54.65	63.39	1	0.9679	0.9802	1.0900	1.0600	1.0581
Bunting Street	PC-28	2022-11-07	2022-12-07	-	145	166	Soaked 48 h	62.48	66.10	1	0.9341	0.9802	1.0900	1.0600	1.0000

Comments

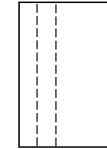
*Correction factors $F_{l/d}$, F_{dia} , F_{mc} , and F_D calculated as per ACI 214.4R-03, and correction factor F_{reinf} calculated as per Khoury et al. (2014): $f_c = f_{conc} F_{l/d} F_{dia} F_{mc} F_D F_{reinf}$



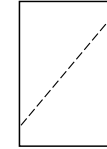
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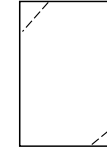
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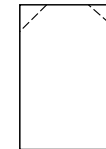
Type 3



Type 4



Type 5



Type 6

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

Signature: *Angela Fidler-Kliewer*

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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].

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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.

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cc. 12 or cc. 15

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	Air dried ^a	$1 - \{0.144 - \alpha f_{core}\} (2 - \frac{1}{d})^2$
(2)	F_{dia} : core diameter	
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	100 mm	1.00
	150 mm	0.98
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	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.

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

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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.

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multiple bars

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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

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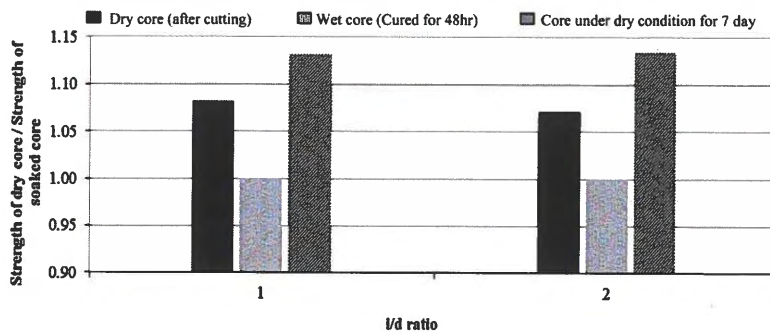


Figure 20 Effect of core moisture condition on core strength for different aspect ratios (l/d).