MEMO

TO: Dawn Blackman Senior Project Manager, Planning, Design, and Construction

FROM: Daniel Wall, P. Eng., M. Eng., (Review by Mo Elsayed, P. Eng., M. Eng.)

SUBJECT: **Carleton Proposed Residence – Retaining Wall Slope Stability**

DATE: **November 22, 2020**

INTRODUCTION

WSP Canada Inc. (WSP) is pleased to submit a memorandum for the global slope stability of the proposed retaining walls at the new university residence building. The overall retaining wall and internal stability analysis has been completed by RJC Engineers as per the memo issued on May 5, 2020. It is recommended that this memorandum be read in conjunction with the geotechnical report and subsequent memos produced by WSP for this project for comprehensive understanding of the existing site conditions.

AVAILABLE INFORMATION

In the preparation of this report, the following information and reports were relied upon:

RJC Retaining Wall Typical Design, OTT.124933.0001, May 2020. (RJC, 2020);

Morrison Hershfield Carleton University New Residence Building Drawing C003, Grading Plan, April 2020. (Grading Plan, April 2020);

Morrison Hershfield Carleton University New Residence Building Drawing C701, Retaining Wall System Profiles, April 2020. (Retaining Wall Profiles, April 2020);

Report On Design Stage Subsurface Investigation For The Proposed Student Residences At The University Commons Building Carleton University, Report No. Sf-2962 June 20, 1989, McRostie, Genest, St-louis & Associates Ltd. (MGSA, 1989)

SLOPE STABILITY ANALYSIS

Global slope stability analysis was conducted for the proposed retaining wall. Slope stability analyses were performed utilizing Geostudio 2020 R2 SLOPE/W (Version 10.2.2) from GEO-SLOPE International Ltd. Slopes were analyzed for short-term and seismic conditions using the Morgenstern-Price method and optimized circular slip surfaces with a minimum slip surface depth of 1.0 m.

A Factor of Safety (F.O.S.) is generally introduced in the slope stability assessments. As per the City of Ottawa requirements a minimum F.O.S. of 1.5 for static conditions and 1.1 for seismic conditions are deemed to be acceptable.

SLOPE PROFILES AND DESIGN PARAMETERS

Slope stability analysis was performed for the following slope sections S1- S1 and S2-S2 as outlined in the Morrison Hershfield Retaining Wall Profiles, dated April 2020. For section S1-S1 borehole BH19-8 from the WSP 2019

investigation as well as borehole 89-7 from the MGSA 1989 investigation were used. Similarly, for section S2-S2 borehole BH19-10 from the WSP 2019 investigation as well as borehole 89-6 from the MGSA 1989 investigation were used. Material parameters used for the analyses were estimated from general index properties, SPT values, published literature and our experience with local conditions. Parameters are summarized in **Table 1**.

Table 1 Material Parameters for Slope Stability Analysis (Effective Stress)

SOIL TYPE	γ (KN/M^3)	C (KPA)	ϕ (DEGREES)
Granular Backfill Material	22	0	28
Sand and Gravel with boulders/cobbles	20	0	30
Glacial Till	19	0	30
Concrete	23.5	--	--
Bedrock	---	---	---

γ = unit weight, ϕ = friction angle, c = cohesion

The parameters for the granular backfill material assume that the material will adhere to the design physical and mechanical properties indicated on the supplied construction drawings.

RESULTS AND RECOMMENDATIONS

GENERAL

The following were the results of the global slope stability analysis. A 19 kPa surcharge was applied the retained backfill to simulate compaction induced stresses.

Table 2 Results of the global slope stability analysis

SECTION	CRITICAL FACTOR OF SAFETY
S1-S1 Static Analysis	3.8
S1-S1 Seismic Analysis	2.2
S2-S2 Analysis	2.5
S2-S2 Analysis	1.7

The factors of safety meet the requirements for stability and are deemed to be acceptable.

BACKFILL AND COMPACTION

The proposed retaining wall should be founded on prepared subgrade and 300 mm of OPSS Granular A compacted to 100% SPMDD, capable of 150kPa minimum bearing capacity. Granular backfill should be placed in shallow lifts, not exceeding 200 mm loose thickness, and compacted to 100% SPMDD (ASTM D698) where it is supporting any structures or services, and 95% in other areas. Adjust moisture content as required for optimum compaction. No organic, deleterious or frozen materials should be used. The granular backfill should be at least 600 m wider than the base of the foundation.

Care should be exercised when compacting fill adjacent to new structures, to prevent damage. Heavy equipment should be kept at least 1 m away from structures during backfilling. The 1m width adjacent to the wall should be compacted using hand-operated equipment unless otherwise authorized.

DRAINAGE, FROST PENETRATION AND EROSION

The site should be properly drained to remove water away from the slopes as quickly as possible. Ponding near the toe of the slope may result in subgrade softening which may lead to slope instabilities.

The depth of frost penetration for the site is inferred to be 1.8m. All foundation elements should therefore have a permanent soil cover of at least 1.8m (or its thermal equivalent if artificial insulation is used) as mention in the Geotechnical Design report associated with this project from WSP.

The embankment slopes should be protected from erosion by applying erosion resistant material on the slope surface (seeded topsoil layer on slopes). The slopes should also be protected from erosion during construction by applying temporary erosion protection mats or some form of erosion control.

Scheduled inspections should be conducted regularly and after heavy precipitation along the excavated slope, the backfill material slope and of the retaining walls during construction to insure the stability of the infrastructure or to note any changes in the structures.

Conclusion

All recommendations presented in this memorandum assume that an adequate level of monitoring will be provided during construction. Suitably qualified persons, independent of the Contractor, should carry out all such quality assurance monitoring. One of the purposes of providing an adequate level of monitoring is to verify that the recommendations provided in this report, which are based on the findings at discrete borehole locations, are relevant to other areas of the site. WSP can provide these services upon request.

We trust that this memorandum addresses the present slope stability analysis requirements for this assignment. Should you have further questions regarding this report, please feel free to contact the undersigned.

WSP Canada Inc.

Prepared by:

Daniel Wall, M.Eng., P. Eng.
Intermediate Geotechnical Engineer

Reviewed by:

Mohamed Elsayed, M.Eng., P.Eng.
Senior Geotechnical Engineer,

Attachments:

- Morrison Hershfield Carleton University New Residence Building Drawing C701, Retaining Wall System Profiles
- Borehole logs 89-6 and 89-7 from MGSA, 1989
- Grading Plan, April 2020
- Retaining Wall Profiles, April 2020

CARLETON UNIVERSITY RESIDENCES	B.M. (EL.63.91m) geodetic : Top of brass	BOREHOLE No. 89-8
START DATE: 16/05/89 -	plate in wall at fire hose connection,	Project No: E-6217
	east corner of exist. women's residence.	ELEVATION 63.17 (m)

SAMPLE TYPE: DISTURBED | SHELBY TUBE | SPLIT SPOON | BW CASING | BX-NO RECOVERY | BX CORE

DEPTH (m)	SMALL PEN. (kPa)	SPT (N)	SAMPLE TYPE	SAMPLE NO	USC	SOIL/ROCK DESCRIPTION	ELEVATION (m)
0.0						ASPHALT 63.10	63.2
		9/15cm 28		1		FILL Fine and medium sand	
1.0		30		2		62.12	62.2
		38/15cm		2A		FILL Sand with some gravel and topsoil 61.67	
		8 6/15cm		3		FILL Clay with some topsoil and pieces of rock	
2.0						60.92	61.2
		12/15cm 76		4			
3.0		18/15cm 91		5		Very dense Coarse and medium SAND with boulders	60.2
		54 47/15cm		6		Water level May 19/89 El. 59.21	59.2
						58.67	
		14/15cm 36		7			
5.0							58.2
		37 52/15cm		8		Dense to very dense Sandy TILL with boulders	
6.0							57.2
		27 18/15cm		9			
		15/15cm 59		10			56.2
7.0		Sand in augers, - BW casing used					
						55.67	
		30/15cm 51		11		Very dense Coarse SAND with some gravel Borehole continued 55.17	
8.0							55.2

VANE CU (kPa): 80 160 240 320
▲ VANE CU REMOULDED (kPa) ▲: 80 160 240 320
PLASTIC M.C LIQUID: 20 40 60 80

McROSTIE GENEST ST.LOUIS
Ottawa, Ontario

COMPLETION DEPTH 16.6 m		COMPLETE 17/05/89
LOGGED BY C.M.	DWG NO.	Page 1 of 2

Plate No. 12

CARLETON UNIVERSITY RESIDENCES	B.M. (EL.62.91m) geodetic : Top of brass	BOREHOLE No. 89-8
START DATE: 16/05/89 -	plate in wall at fire hose connection ,	Project No: E-6217
	east corner of exist. women's residence.	ELEVATION 63.17 (m)

SAMPLE TYPE: DISTURBED | SHELBY TUBE | SPLIT SPOON | BW CASING | NE-NO RECOVERY | HX CORE

DEPTH (m)	SMALL PEN. (kPa)	SPT (N)	SAMPLE TYPE	SAMPLE NO	USC	SOIL/ROCK DESCRIPTION	ELEVATION (m)
8.0						Very dense Course SAND with some gravel — 54.3	55.2
	69 43/15cm			12		Very dense Sandy TILL	
9.0	34/15cm 50/10cm			13		— 53.92	54.2
						Very dense Sandy TILL with boulders	
10.0	47/15cm 30/8cm			14		LIMESTONE rock block (C.R. 42%)	53.2
						LIMESTONE and SHALE rock blocks (C.R. 63%)	
11.0	34/15cm 25/5cm			15		— 51.97	52.2
	Water lost occasionally between : 11.40m and 12.60m					Fractured black limey SHALE (C.R. 50%) — 51.77	
12.0						Fractured black limey SHALE (C.R. 18%) — 51.20	51.2
						Fractured black limey SHALE (C.R. 38%) — 50.67	
13.0						Fractured black limey SHALE (C.R. 50%) — 50.57	50.2
						Black limey SHALE (C.R. 79%)	
14.0						— 49.05	49.2
						Black limey SHALE and shaley LIMESTONE (C.R. 100%)	
15.0							48.2
						Bottom of hole +47.53	
16.0						C.R = Core Recovery	47.2

VANE Cu (kPa): 80 160 240 320
▲ VANE Cu REMOULDED (kPa) ▲: 80 160 240 320
PLASTIC — M.C — LIQUID: 20 40 60 80

McROSTIE GENEST ST.LOUIS Ottawa, Ontario	COMPLETION DEPTH 16.6 m	COMPLETE 17/05/89
	LOGGED BY C.M.	DWG NO.

Plate No. 13

CARLETON UNIVERSITY RESIDENCES	B.M. (EL.63.91m) geodetic : Top of brass	BOREHOLE No. 89-7
START DATE: 12/05/89 -	plate in wall at fire hose connection,	Project No: E-6217
	east corner of exist. women's residence.	ELEVATION 63.15 (m)

SAMPLE TYPE: DISTURBED | SHELBY TUBE | SPLIT SPOON | BW CASING | BX-NO RECOVERY | BX CORE

DEPTH (m)	SMALL PEN. (kPa)	SPT (N)	SAMPLE TYPE	SAMPLE NO	USC	SOIL/ROCK DESCRIPTION	ELEVATION (m)
0.0						ASPHALT 63.08	63.2
		18/15cm 16		1		FILL Sand with some gravel	
		9/15cm		2		62.25	
1.0		38		2A		FILL Crushed stone	62.2
		9 18/15cm		3		61.65	
2.0						FILL Topsoil, sand, gravel, clay and wood	61.2
		23 7/15cm		4			
3.0						60.15	60.2
		15/15cm 64		5		Dense to very dense Coarse SAND and GRAVEL with some medium sand	
						Water level May 16/89 El. 59.53	
		23				59.40	
4.0		29/15cm		6		Water level May 18/89 El. 59.39	59.2
						Medium dense to very dense Sandy TILL with boulders	
		20 35/15cm		7			
5.0						57.90	58.2
		5/15cm 23		8			
6.0							57.2
		3/15cm 19		9		Loose to medium dense Sandy TILL	
		17					
7.0		5/15cm		10			56.2
		Sand in augers, → BW casing used					
		12 14/15cm		11			
8.0						Borehole continued 55.15	55.2

VANE CU (kPa): 80 160 240 320
▲ VANE CU REMOULDED (kPa) ▲: 80 160 240 320
PLASTIC M.C LIQUID: 20 40 60 80

McROSTIE GENEST ST.LOUIS
Ottawa, Ontario

COMPLETION DEPTH 14.6 m | COMPLETE 15/05/89
LOGGED BY C.M. | DWG NO. | Page 1 of 2

Plate No. 14

CARLETON UNIVERSITY RESIDENCES	B.M. (EL.63.81m) geodetic : Top of brass	BOREHOLE No. 89-7
START DATE: 12/05/89 -	plate in wall at fire hose connection ,	Project No: E-6217
	east corner of exist. women's residence.	ELEVATION 63.15 (m)

SAMPLE TYPE: DISTURBED | SHELBY TUBE | SPLIT SPOON | BW CASING | BX-NO RECOVERY | BX CORE

DEPTH (m)	SMALL PEN. (kPa)	SPT (N)	SAMPLE TYPE	SAMPLE NO	USC	SOIL/ROCK DESCRIPTION	ELEVATION (m)
0.0						Loose to medium dense Sandy TILL	63.2
						LIMESTONE rock block 54.78	
9.0		27 54/15cm		12		Medium dense to very dense Sandy TILL with Limestone rock blocks	54.2
						LIMESTONE rock block	
10.0		13/15cm 94		13		Medium dense to very dense Sandy TILL with Limestone rock blocks	53.2
						Fractured black limey SHALE 53.05 (C.R. 41%)	
						Fractured black limey SHALE 52.76 (C.R. 36%)	
						Fractured black limey SHALE 52.48 (C.R. 36%)	
11.0						52.15	52.2
						Black limey SHALE (C.R. 76%)	
12.0							51.2
						50.65	
13.0						BLack limey SHALE (C.R. 95%)	50.2
14.0						Bottom of hole 49.13	49.2
15.0						C.R. = Core Recovery	48.2
16.0							47.2

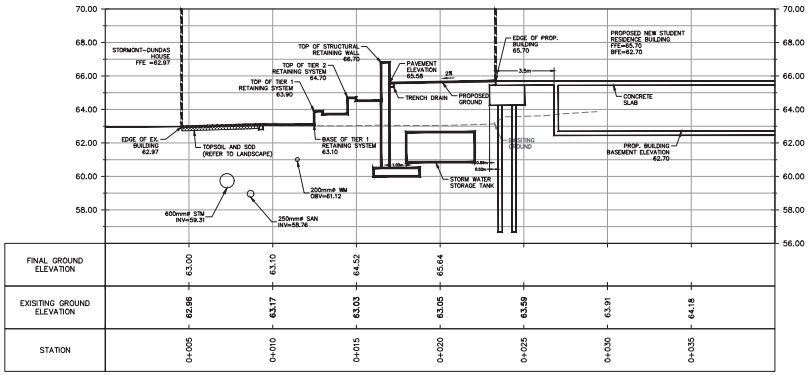
VANE Cu (kPa): 80 160 240 320
▲ VANE Cu REMOULDED (kPa) ▲: 80 160 240 320
PLASTIC M.C LIQUID: 20 40 60 80

Water lost occasionally from 10.67m to 11.00m

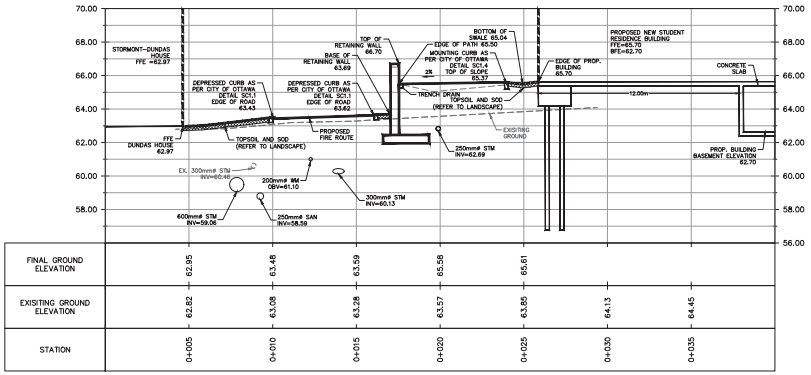
McROSTIE GENEST ST.LOUIS
Ottawa, Ontario

COMPLETION DEPTH 14.0 m	COMPLETE 15/05/89
LOGGED BY C.M.	DWG NO.

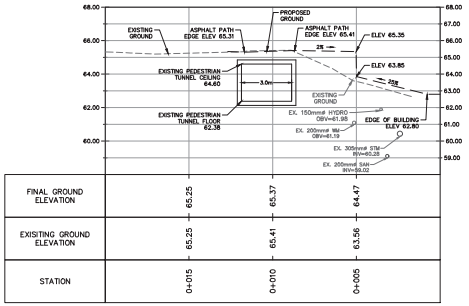
Plate No. 15



S1 C004 RETAINING WALL SECTION



S2 C004 RETAINING WALL SECTION



S3 C004 RETAINING WALL SECTION

×64.74	PROPOSED ELEVATION
× 71.65	EXISTING ELEVATION
× 65.50T	PROPOSED FINISH GRADE AT TOP OF WALL OR STEP
× 63.32B	PROPOSED FINISH GRADE AT BOTTOM OF WALL OR STEP
63.26T/C	PROPOSED TOP OF CURB ELEVATION
2.0%	PROPOSED SLOPE DIRECTION
	DIRECTION OF MAJOR OVERLAND FLOW
	DIRECTION OF EMERGENCY OVERLAND FLOW
	PROPOSED CURB
DC	PROPOSED DEPRESSED CURB
	EMERGENCY SPILL ELEVATION
	HEAVY DUTY PAVEMENT - 40mm HL3 OR SP12.5 PG58-34 - 100mm HL8 OR SP19.0 PG58-34 - 150mm OF GRANULAR A - 450MM OF GRANULAR B
	MILL AND RESURFACE 40mm DEPTH
	ECORASTER PERMEABLE PAVING
	PROPOSED SWALE
	LIMIT OF PROJECT

SCALE 1:150
HORIZONTAL & VERTICAL
0m 1 2 4

MORRISON HERSHFIELD
200-2932 BASELINE ROAD, OTTAWA, ON K2H 1B1

ISSUED

No.	Date	Description
1	07/04/2020	ISSUED FOR FOUNDATION PERMIT

Diamond Schmitt Architects 384 Adelaide Street West Suite 100 Toronto, Ontario M5V 1R7 Canada Tel: 416 862 8800 Fax: 416 862 5508 r90@dsai.ca www.dsai.ca

KWC Architects Inc. 383 Parkdale Avenue Suite 301 Ottawa, Ontario K1Y 4R4 Canada Tel: 613 238 2127 Fax: 613 238 6290 kwc@kwcarch.com www.kwcarch.com

CARLETON UNIVERSITY NEW STUDENT RESIDENCE

CARLETON UNIVERSITY
1125 COLONEL BY DRIVE
OTTAWA ON
K1S 5B6

RETAINING WALL SYSTEM PROFILES

Scale: 1:150
Project No: 190446O0
Date: 04/07/20

C701

May 05, 2020

Jenny Kluke
Development Review, Central Branch
City of Ottawa
110 Laurier Avenue West
Ottawa, ON K1P 1J1

Dear Jenny Kluke:

RE: Consolidation of Engineering Related Comments
1125 Colonel By Drive – New Student Residence Building
File Number: D07-12-19-0205
Consultant File Number: 190444600 **RJC No.: OTT.124933.0001**

RJC has completed the structural design of the proposed retaining wall at the above-noted site, per the below noted city request:

- A retaining wall is proposed to overcome the significant difference in grade between the site and the Stormont-Dundas House and is over 1m in height. As per *City of Ottawa Slope Stability Guidelines for Development Applications* an engineering report is required to be prepared by a qualified engineer for any retaining walls 1m or greater in height that addresses the global stability of the wall. An Internal Compound Stability (ICS) analysis from a professional Geotechnical Engineer/ Structural Engineer licensed in the Province of Ontario is required to check for global stability. The retaining wall is to have a factor of safety of at least 1.5 for static conditions (as calculated through SLIDE) and 1.1 for seismic conditions. The report shall provide structural details of the retaining wall and account for the load from the adjacent underground storage tank. The retaining wall design is required prior to planning approval not at the time of building permit application submission as suggested.

Please refer to the attached structural sketch SSK-S01 for the structural design meeting the above noted city request. Refer to civil drawing C003 for retaining wall extents and soil grades.

Should you have any questions or concerns, please do not hesitate to contact the undersigned at 343-291-1081.

Yours truly,

Read Jones Christoffersen Ltd.

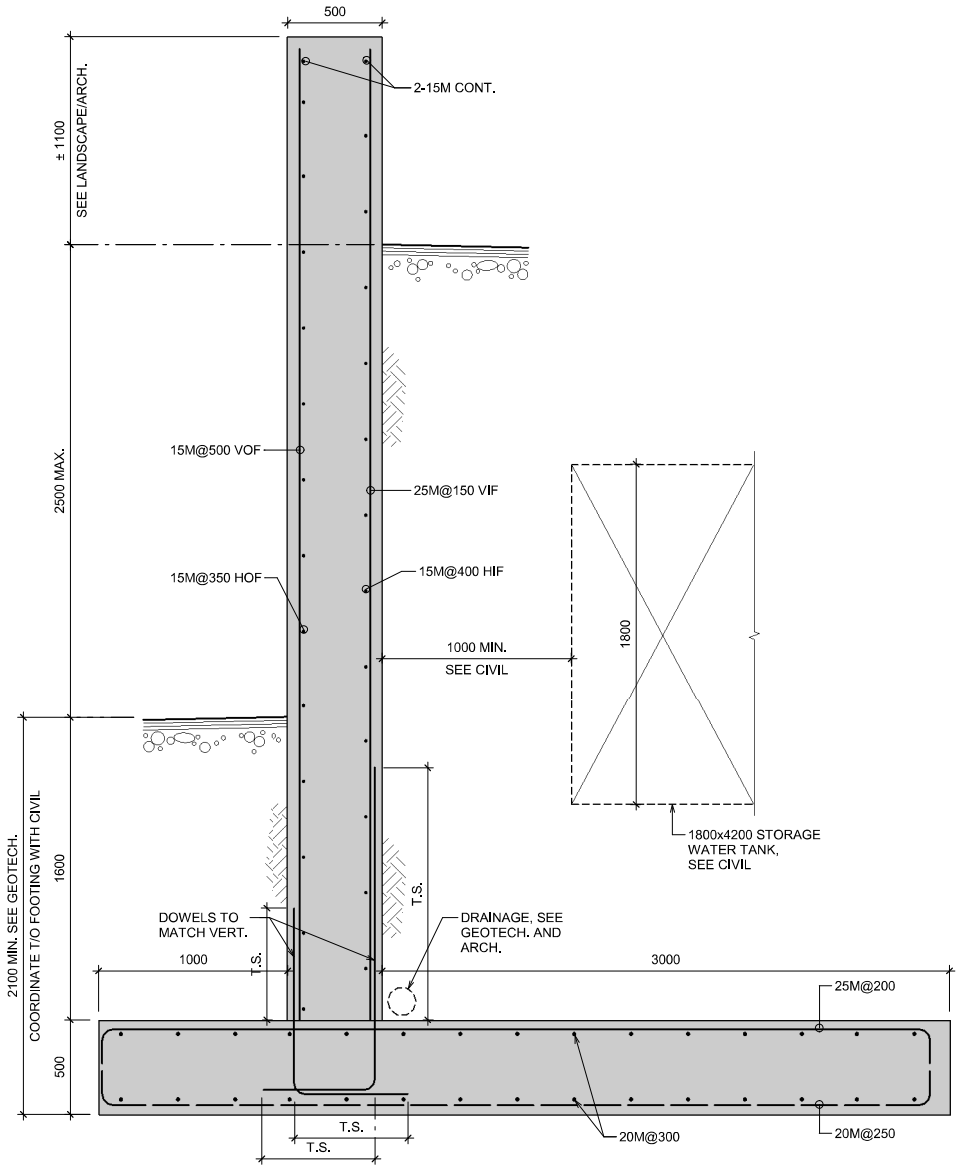
Prepared by:

Alaina Polkki, E.I.T.
Engineering Intern
Structural Engineering

Reviewed by:

Sean Keating, P.Eng.
Regional Manager/Project Engineer
Structural Engineering

Read Jones Christoffersen Ltd. 343 Preston Street, 11th Floor **tel** 343-291-1081 **email** ottawa@rjc.ca
Creative Thinking **Practical Results** Ottawa ON K1S 1N4 **fax** 613-416-9655 **web** rjc.ca



RETAINING WALL NOTES:

1. RETAINING WALLS ARE DESIGNED IN ACCORDANCE WITH THE RECOMMENDATIONS OF THE GEOTECHNICAL REPORT BY WSP (PROJECT #: 191-19248-00) DATED DECEMBER 2019 (REPORT), MARCH 2020 (MEMO), AND APRIL 2020 (MEMO), PLUS A 4.8 kPa LATERAL LOAD ALLOWANCE FOR A VERTICAL SURCHARGE OF 12 kPa. REFER TO GEOTECHNICAL REPORT FOR ALL GEOTECHNICAL REQUIREMENTS.
2. RETAINING WALLS TO BE SUPPORTED ON SOIL CAPABALE OF SUSTAINING:
   SLS: 150 kPa
   ULS: 175 kPa
   SUBGRADE MODULUS: 6000 kN/m3
3. RETAINING WALLS ARE DESIGNED FOR A FREE DRAINING AND WELL DRAINED BACKFILL. SEE ARCHITECTURAL AND CIVIL SPECIFICATIONS AND DRAWINGS FOR DRAINAGE REQUIREMENTS.
4. SEE ARCHITECTURAL DRAWINGS AND SPECIFICATIONS FOR DAMPROOFING OR WATERPROOFING REQUIREMENTS.
5. SEE ALSO ARCHITECTURAL AND CIVIL/LANDSCAPING DWGS FOR EXTENT OF RETAINING STRUCTURES AND LOCATION RELATIVE TO SITE.
6. BACKFILL MATERIALS AND METHODS TO BE REVIEWED BY SOILS CONSULTANT TO ENSURE COMPLIANCE TO THE RECOMMENDATIONS AS NOTED IN THE GEOTECHNICAL REPORT.
7. DESIGN AND FIELD REVIEW OF BACKFILL IS BY SOILS CONSULTANT AND NOT BY READ JONES CHRISTOFFERSEN.
8. UNLESS NOTED OTHERWISE, ALL RETAINING WALLS BELOW GRADE AND ALL EXTERIOR WALLS EXPOSED TO THE WEATHER ABOVE GRADE SHALL HAVE CONTROL JOINTS. CONSTRUCTION JOINT MAY REPLACE CONTROL JOINT WHERE REQUIRED. THE LOCATION OF CONTROL JOINTS IN EXPOSED CONCRETE WALLS SHALL BE SUBMITTED TO THE ARCHITECT FOR REVIEW.

CONCRETE NOTES:

1. COMPRESSIVE STRENGTH OF 35 MPa (MIN.)
2. CONCRETE EXPOSURE CLASS S-3.
3. PROVIDE TYPE HS CEMENT.
4. PROVIDE CONCRETE MIX DESIGN SHOP DRAWING TO RJC FOR REVIEW PRIOR TO CONSTRUCTION.
5. 40mm CLEAR COVER TO REINFORCING U.N.O.

D07-12-19-0205

#18030

rjc Engineers

Project Name
CARLETON UNIVERSITY NEW STUDENT RESIDENCE

Sketch Title
RETAINING WALL TYPICAL DETAIL

Dwg. Ref.	**C001, C003**
Scale	**1:40**
Date	**2020/05/05**
Project No.	**OTT.124933.0001**
Sketch Number	Rev.
SSK-S01	**00**