PATERSON GROUP

memorandum

re: **Geotechnical Review of Rock Anchor Design – General Details**
Proposed Multi-Storey Building
18 Louisa Street Ottawa - Ottawa

to: Jennings Real Estate – **Mr. Ken Jennings** - kjennings@jenningsdevelopments.com
cc: FOTTEN – **Ms. Patricia Warren -** warren@fotenn.com
date: October 30, 2024
file: PG5405-MEMO.02

Further to your request and authorization, Paterson Group (Paterson) has prepared the current memorandum to provide general design and construction recommendations for rock anchor being considered at the subject site. The following memorandum should be read in conjunction with Paterson Group Geotechnical Investigation Report PG5405-1, Revision 3 dated July 24, 2024.

1.0 Background Information

Based on the available information from the above noted geotechnical report, the subsurface profile within the proposed excavation area generally consists of asphalt concrete layer and fill material underlain by bedrock. Bedrock was encountered at the subject site at an average depth of 1.6 m below the existing ground surface and was cored with an average RQD value ranging from 67 to 85% within the upper 1.5 m and an average RQD value of 85 to 100% thereafter.

Groundwater levels were measured on November 25, 2020, within the installed standpipes. Based on these observations, it is estimated that the long-term groundwater table can be expected to range between 2.5 to 3.5 m below the existing grade. However, groundwater levels are subject to seasonal fluctuations and therefore could vary during the time of construction.

Based on the available drawings, it is understood that the proposed development will consist of two underground parking levels. Therefore, a vertical cut through the weathered bedrock face is expected for the majority of the proposed excavation area. Given the poor conditions of the upper 1.5 m of the bedrock, it is expected that bedrock stabilization be required to ensure a safe workplace for the workers moving along the bottom of the excavation. The following summarizes our recommendations for rock anchor design to support the bedrock face during the construction period at the subject site:

2.0 Rock Anchor Design Recommendations

Overview of Anchor Features

The geotechnical design of grouted rock anchors in bedded sedimentary bedrock is based upon two possible failure modes. The anchor can fail either by shear failure along the grout/rock interface or by pullout of a 60 to 90 degree cone of rock with the apex of the cone near the middle of the bonded length of the anchor. Both modes of failure have to be examined, as described in the following subsections. A third failure mode of shear failure along the grout/steel interface should be reviewed by a qualified structural engineer to ensure all typical failure modes have been reviewed.

Anchors can be of the “passive” or the “prestressed/post-tensioned” type, depending on whether the anchor tendon is provided with prestress load or not prior to being put into service. Regardless of whether an anchor is of the passive or prestressed type, it is recommended that the anchor be provided with a bonded length, or fixed anchor length, at the base of the anchor, which will provide the anchor capacity, as well as an unbonded length, or free anchor length, between the rock surface and the start of the bonded length. As the depth at which the apex of the shear failure cone develops midway along the bonded length, a fully bonded anchor would tend to have a much shallower cone, and therefore less geotechnical resistance, than one where the bonded length is limited to the bottom part of the overall anchor.

Grout to Rock Bond

The Canadian Foundation Engineering Manual recommends a maximum allowable grout to rock bond stress (for sound rock) of 1/30 of the unconfined comprehensive strength (UCS) of either the grout or rock (but less than 1.3 MPa) for an anchor of minimum length (depth) of 3 m. Generally, the unconfined comprehensive strength of the limestone ranges between about 75 and 100 MPa, which is stronger than routine grouts. At ULS, a factored tensile grout to rock bond resistance value of **1.0 MPa**, incorporating a resistance factor of 0.3, should be provided. A minimum grout strength of 40 MPa is recommended.

Rock Cone Uplift

As discussed previously, the geotechnical capacity of rock anchors depends on the dimensions of the rock anchors and the anchorage system configuration. Based on existing bedrock information provided from the aforementioned geotechnical report, and assuming that the bond zone will be in competent bedrock located 1 m below the bedrock surface, a **Rock Mass Rating (RMR) of 72** was assigned to the bedrock, and Hoek and Brown parameters **(m and s)** were taken as **0.575 and 0.00293**, respectively.

Recommended Rock Anchor Length

Parameters used to calculate grouted rock anchor lengths are provided in Table 1, below.

Table 1 - Parameters used in Rock Anchor Review	
Grout to Rock Bond Strength - Factored at ULS	1.0 MPa
Compressive Strength - Grout	40 MPa
Rock Mass Rating (RMR) - Good quality Limestone Hoek and Brown parameters	72 m=0.575 and s=0.00293
Unconfined compressive strength - Limestone	75 MPa
Unit weight - Submerged Bedrock	15 kN/m^3
Apex angle of failure cone	60^o
Apex of failure cone	mid-point of fixed anchor length

From a geotechnical perspective, the fixed anchor length will depend on the diameter of the drill holes. Recommended anchor lengths for a 75- and 125-mm diameter hole are provided in Table 2. The factored tensile resistance values provided are based on a single anchor with no group influence effects.

Table 2 - Recommended Rock Anchor Lengths - Grouted Rock Anchor				
Diameter of Drill Hole (mm)	**Anchor Lengths (m)**			**Factored Tensile Resistance (kN)**
	Bonded Length	**Unbonded Length**	**Total Length**	
75	1.7	0.7	2.4	450
	2.2	0.7	2.9	600
	2.7	0.6	3.3 *	750
	3.3	0.5	3.8	900
125	1.0	1.0	2.0	450
	1.3	1.1	2.4	600
	1.6	1.2	2.8 *	750
	1.9	1.2	3.1	900
* Indicates the recommended lengths required to provide proper temporary bedrock stabilization during construction.				

3.0 Rock Anchor Installation Recommendations

The following rock support program may consist of rock anchors, rock bolting, and rock protection measures to stabilize the rock mass and/or the upper weathered portion. Possible bedrock stabilization requirements are presented below and in Figure 1 attached to this memorandum:

- Prior to the application of the stabilization measures, the bedrock face should be cleaned from any loose material using a hydraulic shovel, air compressor, hand tools, or pressure washing if weather conditions allow pressure washing to be completed. If pressure washing is used, it is recommended that multiple sumps be running to remove the excess water from the bottom of the excavation immediately.
- If bedrock with mud seams is observed during excavation, the bedrock should be cleaned of a significant amount of the soil and be in-filled with a minimum of 15 MPa concrete. The concrete in-filled area should be reinforced with 15M rebars, extending a minimum of 600 mm into the bedrock to establish a connection between the bedrock to the in-filled concrete.
- Once the bedrock face is reviewed and approved by Paterson, the bedrock face should be ground to a smoother face which allows to extraction of the looser materials and clean the face of the bedrock. Rock grinding will also reduce the possibility of bedrock over breaks often created by hoe-ramming. Furthermore, grinding will produce a smoother vertical surface which facilitates the architectural drainage and dampproofing details.
- Following bedrock face preparation, chainlink fencing with a woven geotextile layer, such as Terratrack 200 or approved equivalent, should be placed against the upper portion of the bedrock face to stabilize any loose rock present within the upper 1.5 m of the excavation face. The chainlink fencing should extend at least 0.5 m below the lowest row of anchors and be secured using rock wedge bolts along the top and bottom of the chainlink panels. The installation of rock anchors such as Swellex rock bolts or approved equivalent extending at least 3.3 m for 75 mm diameter anchors and 2.8 m for 125 mm diameter anchors into the bedrock face at approximately 25 to 30 degrees below the horizontal, will further secure the chainlink fence in place.
- Each chainlink panel should be overlapped by the adjacent chainlink panel with a minimum of 0.5 m and secured using the Swellex rock anchors or approved equivalent. The upper portion of the chainlink fence should be secured to the top of the bedrock surface with a minimum horizontal setback of 600 mm from the vertical bedrock face using a series of minimum 300 mm length rock wedge bolts spaced no greater than 600 mm apart. A 19 mm (3/4 in) sheet of Plywood can be used to secure the bottom of the chainlink panel by anchoring it into the good quality bedrock surface using a series of minimum 300 mm length rock wedge bolts spaced no greater than 600 mm apart.

- It is expected that up to 2 rows of rock anchors are to be installed along the bedrock face. The first row will be placed approximately 0.5 m down from the bedrock surface spaced at 3 m centre horizontally. The lower row of the rock anchors should be staggered by a minimum of 1.5 m from the upper row and a maximum vertical spacing of 1.5 m.
- The number of rows and length of the rock anchors may be changed upon exposing the bedrock surface and revealing the bedrock conditions. If the weathered bedrock is deemed deeper than anticipated, Paterson may add additional rows or increase the vertical spacing of the subject rows to accommodate the deeper weathered bedrock layers.

4.0 Other Recommendations

The anchor drill holes should be a maximum of 1.5 to 2 times the rock anchor diameter, inspected by Paterson personnel, and should be flushed clean prior to grouting. A tremie tube is recommended to place grout from the bottom of the anchor hole. Compressive strength testing is recommended to be completed for the rock anchor grout. A set of grout cubes should be tested for each day that grout is prepared.

The geotechnical capacity of each rock anchor should be proof tested at the time of construction and reviewed at the time of testing by Paterson field personnel. More information on proof testing can be provided upon request.

Once the bedrock is exposed if any different site conditions are observed, Paterson should be notified immediately to assess the bedrock face condition and provide or modify the rock anchor design recommendations appropriate for the bedrock condition. The bedrock stabilization measures identified above should also be periodically inspected by Paterson for validation and documentation purposes.

We trust that the current submission meets your immediate requirements.

Best Regards,

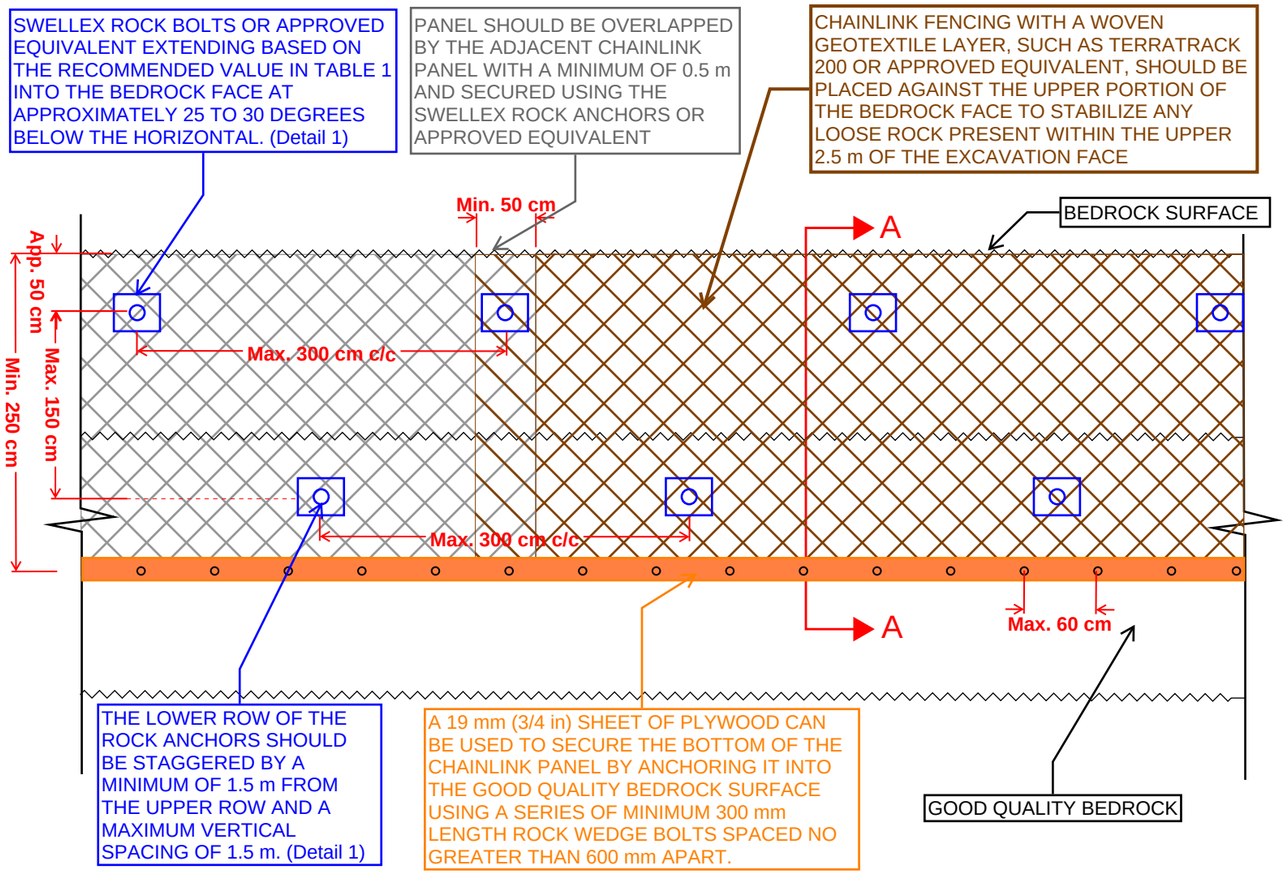
Paterson Group Inc.

Ghodratollah Jahangiri, M.Sc.

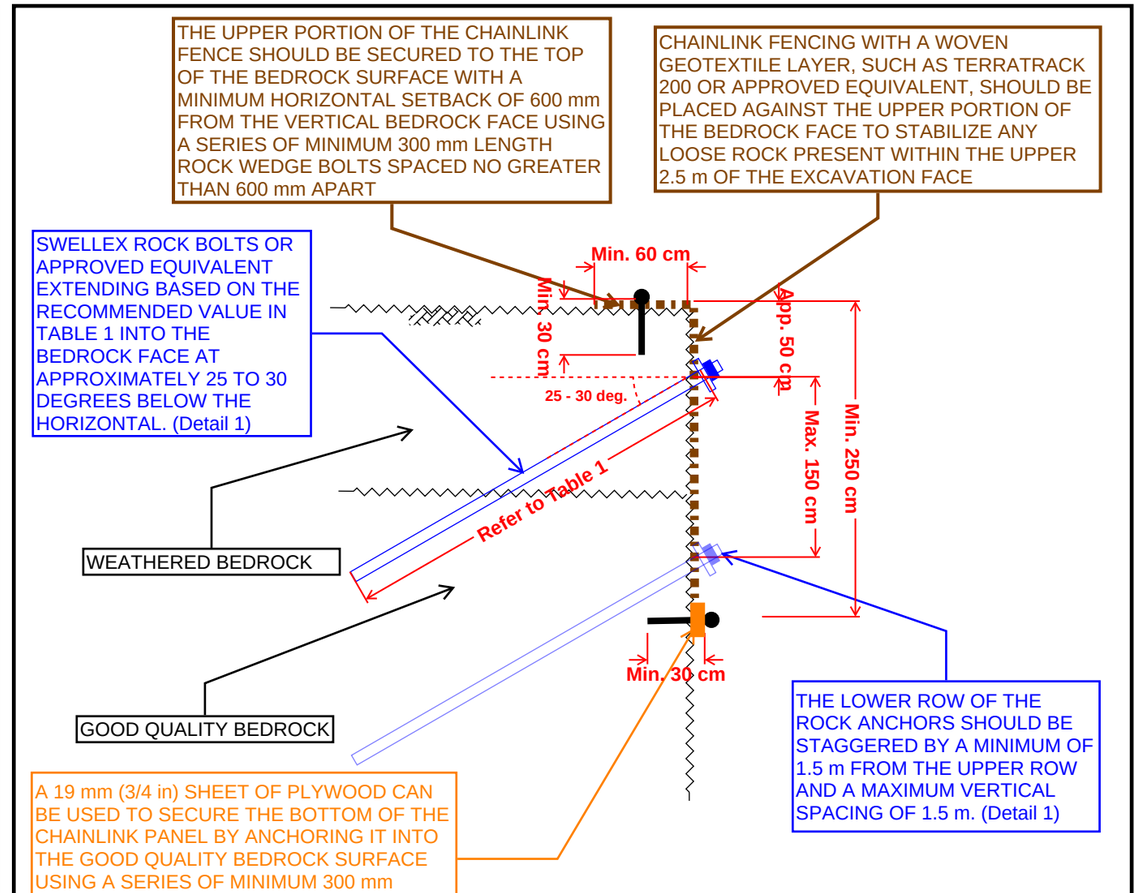
Faisal I. Abou-Seido, P.Eng.

Attachments:

❑ Figure 1 – Geotechnical Review of Rock Anchor Design – General Details



TYPICAL ELEVATION



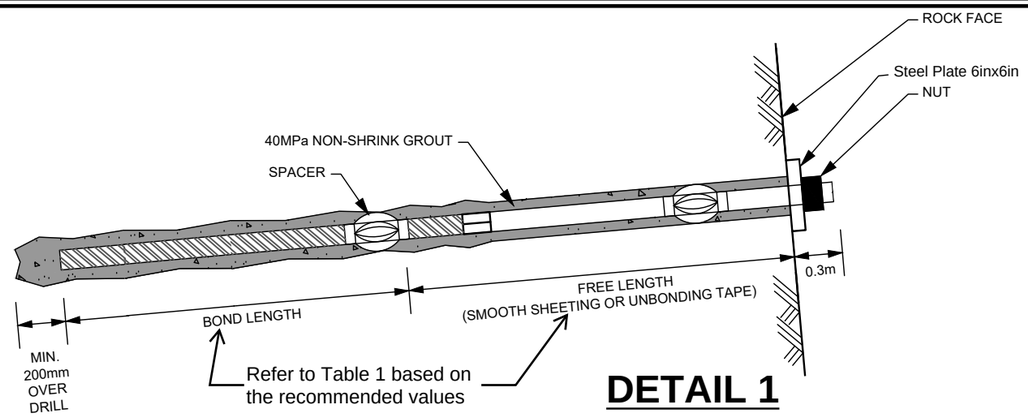
SECTION A-A

THE NUMBER OF ROWS AND LENGTH OF THE ROCK ANCHORS MAY BE CHANGED UPON EXPOSING THE BEDROCK SURFACE AND REVEALING THE BEDROCK CONDITIONS.

ONCE THE BEDROCK IS EXPOSED, IF ANY DIFFERENT SITE CONDITIONS ARE OBSERVED, PATERSON SHOULD BE NOTIFIED IMMEDIATELY TO ASSESS THE BEDROCK FACE CONDITION AND PROVIDE OR MODIFY THE ROCK ANCHOR DESIGN RECOMMENDATIONS APPROPRIATE FOR THE BEDROCK CONDITION.

IT SHOULD BE NOTED THAT THE ROCK ANCHOR DESIGN AND INSTALLATION RECOMMENDATIONS PROVIDED IN THIS DRAWING ARE ONLY APPLICABLE FOR THE SUBJECT SITE.

ALL FIELD WORK SHOULD BE COMPLETED UNDER THE SUPERVISION OF PATERSON PERSONNEL ONCE THE BEDROCK IS EXPOSED.



DETAIL 1

PATERSON GROUP

Jennings Real Estate
Proposed Multi-Storey Building Development
18 Louisa Street,

Ottawa, **ONTARIO**

Title:

Geotechnical Review of Rock Anchor Design – General Details

Scale: N.T.S.	**Date:** 10/2024
Drawn by: GJ	**Report No.:** PG5405-MEMO.02
Checked by: FA	**Drawing No.:** FIGURE 1
Approved by: FA	**Revision No.:**