Geotechnical Investigation
Clarence Arena Emergency Exit Stair Rehabilitation
418 Lemay Street
Clarence-Creek, Ontario

Prepared for

The City of Clarence-Rockland
Attn: Ms. Monique Paquette, Administrative Assistant – Community Services
1560 rue Laurier Street
Rockland, Ontario
K4K 1P7

By

Lascelles Engineering & Associates Limited
1010 Spence Avenue – Suite 14
Hawkesbury, Ontario
K6A 3H9

LASCELLES
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TABLE OF CONTENTS

TABLES

APPENDICES

1 INTRODUCTION

The City of Clarence-Rockland retained the services of Lascelles Engineering & Associates Ltd. (Lascelles) to conduct a geotechnical investigation in relation to the rehabilitation of the emergency exit stairs to the second storey of the Clarence-Creek Arena. The arena is located at 418 Lemay Street in the Village of Clarence-Creek.

The purpose of the investigation was to identify the subsurface soil and groundwater conditions within the proposed project area by means of a limited number of test pits, and based on the factual information obtained, provide guidelines on the geotechnical engineering aspects of the design of the proposed foundations, including construction considerations which may influence the said design.

Should there be any changes in the design features, which may relate to the guidelines provided in the report, Lascelles Engineering & Associates Ltd. should be advised in order to review the report recommendations.

2 PROJECT AND SITE DESCRIPTION

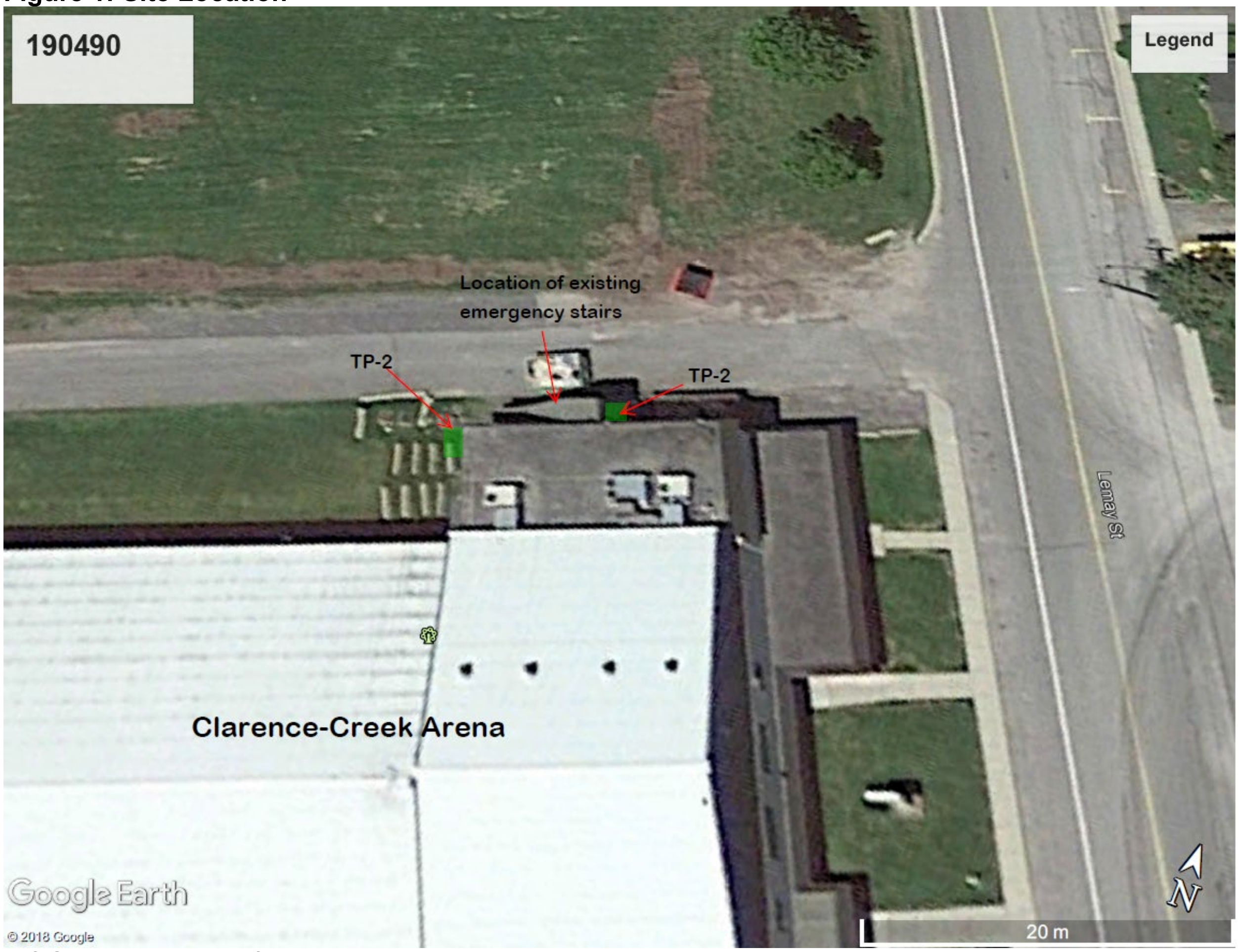
The Clarence-Creek arena is located within the central portion of the Village of Clarence-Creek, Ontario. The stairs to be rehabilitated are located along the north side of the building that provides emergency exit to the second storey of the building. Refer to **Figure** 1 for location.

It is our understanding that the project will consist of removing the existing stairs and replacing them with a new fully enclosed steel frame structure supported on concrete piers, which would be located at the same location.

3 PROCEDURE

The fieldwork for this investigation was carried out on December 6th, 2019 and consisted of digging two (2) test pits; one on each side of the existing stairs. Prior to any fieldwork, the test pit locations were cleared for the presence of any underground services and utilities by the City of Clarence-Rockland. The approximate locations of test pits are shown below as part of **Figure 1**.

Figure 1: Site Location



Ref: Google Earth - Date of Image 2018

The test pits were completed using a backhoe supplied and operated by Poupart Excavation as well as manually digging along the foundation wall. The test pits were taken down to the underside of the footings of the existing building, which was approximately 1.3m below ground surface (bgs). At the location of TP-1, a manual borehole was carried out from 1.3m to 3.3m bgs, in order to characterise the occurring founding soil. The borehole was drilled using a small manual auger with along with a field vane to obtain the shear strength of the cohesive soil. Furthermore, the existing footings of the building were measured. Upon completion, the test pits were backfilled with the excavated fill materials and lightly compacted.

The fieldwork was supervised throughout by a member of our engineering staff who supervised the digging of the test pits, carried out the manual borehole and soil testing and logged the subsurface conditions encountered at each location.

4 SUBSURFACE SOIL AND GROUNDWATER CONDITIONS

4.1 General

A review of the surficial geology maps for this area suggests that the site would be within Reworked Marine Sediments (ancient landslide areas), which generally consist of clay with overlying sand or admixed sand. The drift thickness within this area would vary between 5 to 10m.

The subsurface conditions encountered in the test pits were classified based on visual and tactile examination of the materials recovered from the test holes and the results of the in-situ testing and field observations. The soil descriptions presented in this report are based on commonly accepted methods of classification and identification of soil, employed in geotechnical practice. Classification and identification of soil involves judgement and Lascelles does not guarantee descriptions as exact, but infers accuracy to the extent that is common in current geotechnical practice.

The subsurface soil conditions encountered at each test pit location are given in the Test Pit Logs presented in **Appendix A**. These logs indicate the subsurface conditions encountered at specific test locations only. Boundaries between zones on the logs are often not distinct, but are rather transitional and have been interpreted.

4.2 Topsoil

A thin (150mm) layer of topsoil was encountered in both test pits dug at this site. The topsoil is described as dark brown sandy loam. Crushed stone was found mixed with the topsoil in TP-1. The topsoil was found resting over fill material in both test pits.

The material classified as topsoil was based on colour and the presence of organic materials and is intended as identification for geotechnical purposes only. This does not constitute a statement as to the suitability of this layer for cultivation and sustaining plant growth.

4.3 Fill

Fill material was found underlying the topsoil in both test pits and along the foundation walls. In TP-1, the fill is described as fine-grained to silty sand with traces of clay, and traces of organics. It is brown to greyish brown in colour and in a compact state of packing and moist. In TP-2, the fill is described as fine-grained to silty sand, brown in colour, compact and moist. At 0.9m bgs, a 450mm crushed stone layer was encountered where water infiltration was observed. In both test pit, the fill was found resting over native clay.

4.4 Clay

Both test pits were terminated at the start of the clay layers, which is also the founding stratum of the existing building's foundations. TP-1 was advance further into the clay deposit using a manual auger. The clay is described as being silty and greyish brown in colour with reddish bands. Based on the field vane measured taken within the clay stratum, its consistency was established to be stiff to firm with depth (Cu from 90kPa to 32 kPa). The manual borehole was terminated within the clay deposit at a depth of 3.30m bgs.

4.5 Groundwater Conditions

Groundwater infiltration within the test pit was observed from the crushed stone layer encountered in TP-2 and also from the foundation drain observed running along the top of the footing.

It should be noted that the groundwater table can easily fluctuate with seasonal weather conditions (i.e.: rainfall, droughts and underground service trenches or ditches at or in the vicinity of the site.

4.6 Existing Foundations

Both test pits exposed the existing foundation down to the underside of footings. Lascelles staff took measurements of the exposed foundations, that included depth to the underside of footing, extent of edge of footing from face of foundation wall, thickness of footing and presence of a foundation drain.

It is noted that during the excavation activities, visual and olfactory evidences (soil staining, petroleum sheen on the water, and strong petroleum smell) was observed, especially coming from the water entering the excavation from the foundation drain. It is noted that the foundation drains consist of old clay pipe of which was damaged. No soil or water samples were collected at the time as Lascelles staff did not have the necessary equipment or laboratory jars/bottles for environmental sampling. However, it would appear that the petroleum hydrocarbon contamination would be related to heating oil or diesel.

Sketch drawings of the existing building's foundations measured at the test pit location are provided as part of **Appendix B** as well as photographs in **Appendix C**.

5 GEOTECHNICAL CONSIDERATIONS

5.1 General

This section of the report provides general engineering guidelines on the geotechnical design aspects of the project based on our interpretation and review of the information obtained from the boreholes as well as the project requirements.

It is our understanding that the project will consist of removing the existing stairs and replacing them with a new fully enclosed steel frame structure supported on concrete piers, which would be located at the same location. Refer to **Figure 1**.

5.2 Foundations

Based on the subsurface soil conditions encountered at this site, it is recommended that the foundations for the proposed emergency stairs be founded over undisturbed native clay. Consequently, all organics and fill material will need to be removed from the proposed stair structure footprint. Conventional strip and pad footings set over undisturbed native clay may be designed using a maximum allowable bearing pressure of **75 kPa for serviceability limit state (SLS)** and **115 kPa for ultimate limit state (ULS)** factored bearing resistance. Any new footings set directly adjacent to the existing footings should match its founding depth in order not to undermine or disturb the existing founding stratum.

5.3 Settlement

Provided that all organic soil and any loose and/or disturbed soil is removed from the bearing surfaces prior to pouring the concrete, the estimated total settlement of the foundation, designed using the recommended serviceability limit state capacity value given herein, as well as other recommendations provided above, will be less then 25mm.

It is recommended that a full construction joint provided between the new and existing building structures to allow for differential settlement between the two building structures.

5.4 Grade Raise Restrictions

It is our understanding that grade raises are not required for this project and the finish ground around the new stairs would match the existing grades as seen today.

5.5 Structural Fill

Where excavation below the underside of the footing is performed, consideration shall be given to support the footings on structural fill. The structural fill must extend 0.6m beyond the outside edge of the footings and extend outward and down at a 1 Horizontal to 1 Vertical profile out from the edge equal to the depth of the structural fill set below the footing. The recommended material to be used as structural fill to support the footings shall consist of Granular B Type II crushed stone, or an approved equivalent material.

The structural fill shall be placed over undisturbed native soils in layers not exceeding 300mm and compacted to a minimum of 98 percent of its Standard Proctor Maximum Dry Density (SPMDD) as per ASTM D-698. Prior to placing any structural fill or to pouring the footings, it is required that any disturbed soils along the base of the footing be removed and that the subgrade soils be inspected and approved by the geotechnical engineer. Furthermore, the structural fill must be tested to ensure that the specified compaction level was achieved.

5.6 Seismic Design

Based on the results of the geotechnical investigation, the subsurface at this property can be classified as a Class “E” as per the Site Classification for Seismic Site Response in accordance with the latest version of the Ontario Building Code. It is noted that a greater seismic site response class may be obtained by carrying out seismic velocity testing using a multichannel analysis of surface waves (MASW).

5.7 Liquefaction Potential

Based on the characterisation of the subsurface soil conditions established at this site, the potential of soil liquefaction is not considered to be a concern.

5.8 Slab-on-Grade Construction

For predictable performance of proposed concrete slab-on-grade, it is recommended that they rest over native soil or structural fill only. Therefore, all organic, deleterious or objectionable fill material, including contaminated soil, encountered shall be removed from the building’s footprint.

The exposed native subgrade surface should then be inspected and approved by geotechnical personnel. Any evidently soft areas should be sub-excavated and replaced with suitable engineered fill; however, disturbances should be minimized as much as possible.

Any underfloor fill needed to raise the general floor grade shall consist of OPSS Granular B Type I material or an approved equivalent, compacted to minimum of 95 percent of its SPMDD. The final lift shall be compacted to minimum of 98 percent of its SPMDD. A 200mm layer of OPSS Granular A material shall be placed under the slab and compacted to at least 98 percent of the SPMDD.

In order to minimize and control cracking, the floor slab should be provided with wire or fibre mesh reinforcement and crack control joints. The crack control joints should be spaced at equal distance in both directions and where possible not exceeding a spacing of 4.5 metres. The mesh reinforcement should be carried through the joints.

5.9 Frost Protection

All exterior footings, and those located in any unheated portion of the proposed building should be provided with at least 1.5m of earth cover for frost protection purposes. Exterior footings constructed in areas that are to be cleared of snow during the winter period should be provided with at least 1.7m of earth cover for frost protection purposes. Alternatively, the required frost protection could be provided using a combination of earth cover and extruded polystyrene insulation. Lascelles should review the detailed design of frost protection with the use of equivalent insulation prior to construction.

In the event that foundations are to be constructed during winter months, foundation soils are required to be protected from freezing temperatures using suitable construction techniques. Therefore, the base of all excavations should be insulated from freezing temperature immediately upon exposure, until the time that heat can be supplied to the building interior and footings have sufficient soil cover to prevent freezing of the subgrade soils.

5.10 Foundation Drainage

Considering that the proposed new stair structure will not have basements, permanent perimeter drainage is not required. In order to reduce the potential for ponding of water adjacent to the foundation walls, roof water should be controlled by a roof drainage system that directs water away from the building and the exterior grade should be sloped to promote water being diverted away from the foundation walls.

The perimeter drainage of the existing building should be repaired and reinstated and reviewed, if it is still required.

5.11 Foundation Wall Backfill

To prevent possible foundation frost jacking of foundation wall, the backfill material should consist of free draining, non-frost susceptible material such as sand or sand and gravel meeting OPSS Granular B Type I grading requirements.

The foundation fill should be compacted in 300mm thick lifts, and to 95 percent of its SPMDD using light compaction equipment, where no loads will be set over top. Where the backfill material will ultimately support a pavement structure, walkways or slabs, it is suggested that the foundation wall backfill material be compacted in 200mm thick lifts, and to 98 percent of the SPMDD. The backfilling against foundation walls should be carried out on both sides of the wall at the same time.

5.12 Retaining Walls and Shoring

The following **Table 1** below provides the suggested soil parameters for the design of retaining wall and/or shoring systems. For excavations near existing services and structures, the coefficient of earth pressure at rest (K_o) should be used.

Table 1: Material Properties for Shoring and Permanent Wall Design (Static)

Type of Material	Bulk Density (kg/m^3)	Pressure Coefficient	
		Active (K_a)	At Rest (K_o)
Clay	18	0.45	0.80
Sand	19	0.33	0.50
Till	22	0.27	0.50
Granular B Type I	20	0.33	0.50
Granular B Type II	23.1	0.31	0.47
Granular A	23.5	0.27	0.43

The above values are for a flat surface behind the wall, a straight wall and a wall friction angle of 0 degrees. The designer should consider any difference between these coefficients, and make appropriate corrections for a sloped surface behind the wall, angled wall or wall friction as required. The bearing capacity for the design of a retaining wall are the same as provided for the building structures provided it is founded over native soil or properly prepared and approved structural fill.

Retaining walls should also be designed to resist the earth pressures produces under seismic conditions. The use of the combined coefficients of static and seismic earth pressure is recommended, referred to as K_{AE} for active conditions and K_{PE} for passive conditions for routine design purposes.

The total active and passive loads under seismic conditions can be calculated using the following two equations;

$P_{AE} = ½ K_{AE} \gamma H^2 (1-k_V)$
$P_{PE} = ½ K_{PE} \gamma H^2 (1-k_V)$
Where;
K_{AE} = Combined Static and Seismic Active Earth Pressure Coefficient
K_{PE} = Combined static and seismic passive earth pressure coefficient
H = Total Height of the Wall (m)
K_h = horizontal acceleration coefficient
K_v = vertical acceleration coefficient
γ = bulk density (kg/m^3)

These equations are based on a horizontal slope behind the wall and a vertical back of the retaining wall and zero wall friction. For this site, the following design parameters were used to develop the recommended K_{AE} and K_{PE} values.

A = Zonal acceleration ratio = 0.31
K_h = Horizontal acceleration coefficient = 0.1
K_V = Vertical acceleration coefficient = 0.067

The above value of K_h corresponds to ½ of the A value and the value K_V of corresponds to 0.67 of the K_h value. The angle of friction between the soil and the wall has been set at 0^o to provide a conservative estimate. The following **Table 2** provides the parameters for seismic design of retaining structures.

Table 2: Material Properties for Shoring and Permanent Wall Design (Seismic)

Parameter	OPSS Granular B Type I	OPSS Granular A, Granular Fill and Granular B Type II	Clay and Clayey Material
Bulk Unit Weight, γ (kN/m^3)	20	23.3	18
Effective Friction Angle (degrees)	30	32	28
Angle of Internal Friction Between wall and Backfill (degrees)	0	0	0
Yielding Wall			
Active Seismic Earth Pressure Coefficient (K_{AE})	0.37	0.33	0.45
Height of the Application of P_{AE} from the base of the wall as a ration of its height (H)	0.36	0.37	0.36
Passive Seismic Earth Pressure Coefficient (K_{PE})	3.06	3.48	4.0
Height of the Application of P_{PE} from the base of the wall as a ration of its height (H)	0.30	0.30	0.30

6 EXCAVATION AND GROUNDWATER CONTROL

6.1 Excavation Requirements

It is anticipated that shallow excavation for this project will not exceed 1.5m bgs for the construction of foundation of the emergency stairs. Most of the shallow excavation will be through topsoil and fill as well as potentially native clay.

According to the Ontario's Occupational Health and Safety Act (OHSA), O. Reg. 213/91 and its amendments, the surficial overburden soil anticipated to be excavated into at this site can be classified as Type 3 for fully drained excavations. Therefore, shallow temporary excavation in the overburden soil classified as Type 3 can be cut at 1 horizontal to 1 vertical for a fully drained excavation starting at the base of the excavation and as per requirements of the OHSA regulations.

The listed slopes are for fully drained excavations. Gentler slopes could be required under undrained excavations or below the water table, where localised water infiltrations can occur and where the excavations are exposed for a prolonged period of time.

Any excavated material stockpiled near a trench or open excavation should be stored at a distance equal to or greater than the depth of the excavated soil within the trench or open excavation and equipment circulation should be restricted away from the top of the slope excavation.

In the event that the aforementioned slopes are not possible to achieve due to space restrictions, the excavation should be shored according to OHSA O. Reg. 213/91 and its amendments. A geotechnical engineer should design and approve the shoring and establish the shoring depth under the excavation profile. Refer to the parameters provided in Tables 1 and 2 in Section 5.12 for use in the design of any shoring structures. The excavation for the underground services could be carried out within tightly fitting, braced steel trench boxes, approved by a professional engineer.

6.2 Groundwater Control

Groundwater seepage and infiltration entering shallow and temporary excavations performed within the overburden should be mitigated by pumping from sumps installed in the excavation. Surface water runoff into the excavation should be avoided and diverted away from the excavation.

7 ENVIRONMENTAL CONSIDERATIONS

As noted herein, potential petroleum hydrocarbon soil and groundwater contamination was observed in the two test pits dug at this site. Contractors involved in the project should review any environmental reports prepared for this project with regard to health and safety, as well as excavating, handling and disposing of excess soil as well as groundwater.

8 CONSTRUCTION CONSIDERATIONS

It is suggested that the final design drawings for the site, including the proposed site grading plan, be reviewed by the geotechnical engineer to ensure that the guidelines provided in this report have been interpreted as intended.

The engagement of the services of the geotechnical consultant during construction is recommended to confirm that the subsurface conditions throughout the proposed development do not materially differ from those given in the report and that the construction activities do not adversely affect the intent of the design. All footing areas and any engineered fill areas (if required) for the proposed building should be inspected by Lascelles Engineering and Associates Ltd. to ensure that a suitable subgrade has been reached and properly prepared. The placing and compaction of any granular materials beneath the foundations (if required) should be inspected to ensure that the materials used conform to the gradation and compaction specifications.

The subgrade for the pavement areas and underground services should be inspected and approved by geotechnical personnel. In-situ density testing should be carried out on the slab on grade granular materials, pavement granular materials, pipe bedding and backfill to ensure the materials meet the specifications from a compaction point of view.

9 REPORT CONDITIONS AND LIMITATIONS

It is stressed that the information presented in this report is provided for the guidance of the designers and is intended for this project only. The use of this report as a construction document is neither intended nor authorized by Lascelles Engineering & Associates Ltd. Contractors bidding on or undertaking the works should examine the factual results of the investigation, satisfy themselves as to the adequacy of the information for construction, and make their own interpretation of the factual data as it affects their construction techniques, schedule, safety and equipment capabilities.

The professional services for this project include only the geotechnical aspects of the subsurface conditions at this site. The presence or implications of possible subsurface contamination resulting from previous uses or activities at this site or adjacent properties, and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this report.

The recommendations provided in this report are based on subsurface data obtained at the specific test locations only. Experience indicates that the subsurface soil and groundwater conditions can vary significantly between and beyond the test locations. For this reason, the recommendations given in this report are subject to a field verification of the subsurface soil conditions at the time of construction.

The report recommendations are applicable only to the project described in the report. Any changes to the project will require a review by Lascelles Engineering & Associates Ltd., to ensure compatibility with the recommendations contained in this project.

We trust this report provides sufficient information for your present purposes. If you have any questions concerning this report or if we may be of further services to you, please do not hesitate to contact our office.

Yours truly,
Lascelles Engineering & Associates Ltd.

Prepared by:

Shuang Chang, P. Eng.

Reviewed by:

Mario Elie, Project Manager

LICENSED PROFESSIONAL ENGINEER
S. CHANG
100524774
December 20, 2019
PROVINCE OF ONTARIO

Appendix A

Test Pit Logs

Appendix B

Foundation Sketch and Photographs