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Geotechnical Investigation
Proposed Addition
100 Terence Matthews Crescent
Crescent
Ottawa, Ontario

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Submitted to:

DS Studio
95 Pelham Avenue
Toronto, Ontario
M6N 1A5

Geotechnical Investigation
Proposed Addition
100 Terence Matthews Crescent
Ottawa, Ontario

October 6, 2022
Project: 101873.001

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October 6, 2022 File: 101873.001

DS Studio
95 Pelham Avenue
Toronto, Ontario
M6N 1A5

Attention: Leila Emmrys

Re: Geotechnical Investigation
Proposed Addition
100 Terence Matthews Crescent
Ottawa, Ontario

Please find enclosed our geotechnical investigation report for the above noted project. This report was prepared by Mr. Pawandeep Singh, M.Eng. and reviewed by Mr. Alex Meacoe, P.Eng.

Pawandeep Singh, M.Eng.
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PS/WAM/DC

Enclosures
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1.0 INTRODUCTION

This report presents the results of a geotechnical investigation carried out for the proposed addition to the existing structure located at 100 Terence Matthews Crescent in Ottawa, Ontario.

The purpose of the investigation was to identify the general subsurface and groundwater conditions at the site by means of a limited number of boreholes and, based on the factual information obtained, to provide engineering guidelines on the geotechnical design aspects of the project, including construction considerations that could influence design decisions.

This investigation was carried out in accordance with our proposal to DS Studio dated May 24, 2022.

2.0 BACKGROUND

2.1 Project Description

The following is known about the site and project based on information provide by DS Studio:

- The site is located at 100 Terence Matthews Crescent on the north side of the roadway;
- The overall site is approximately rectangular in shape with an existing one storey commercial building in the southern/central portion, and an at-grade parking lot on the west side;
- It is understood that the proposed addition will be an approximate 930 square metre in plan area and will be of slab on grade construction (i.e., no basement level). The addition will be constructed on the vacant (grass covered) land to the north of the existing structure;
- The finished floor elevation for the proposed building addition will be at an elevation of about 101.7 metres;
- Low rise commercial developments have been constructed on the surrounding lands to the north, south, east and west.

The proposed location of the addition is shown on the Site Plan, Figure 1. No further details of the existing structure on the site or the proposed addition were provided to GEMTEC.

2.2 Site Geology

Based on our review of available borehole data in the area of the site, Ministry of the Environment, Conservation and Parks (MECP) water well records, and published geological mapping, it is expected that the site is underlain by deposits of silty clay. Bedrock geology and drift thickness maps indicate that the overburden is underlain by interbedded limestone and shale bedrock of the Verulam formation at depths ranging from about 5 to 10 metres.

No records of previous geotechnical investigations (for instance for the current structure on site) were provided to GEMTEC for consideration. If such information is available it should be made available.

3.0 SUBSURFACE INVESTIGATION

The fieldwork for the geotechnical investigation was carried out on July 8, 2022. During that time, two boreholes (numbered 22-01, and 22-02) were advanced at the locations shown on the Site Plan, Figure 1.

The boreholes were advanced with a track mounted drill rig supplied and operated by CCC Geotechnical and Environmental Drilling of Ottawa, Ontario.

The boreholes were advanced to depths of about 8.2 metres below the existing ground surface. Standard penetration tests were carried out in the boreholes at regular intervals of depth and samples of the soils encountered were recovered using a 50 millimetre diameter drive open sampler. In-situ vane shear testing was carried out, where possible, in the boreholes to measure the undrained shear strength of the silty clay. Two relatively undisturbed samples of the silty clay deposit were obtained from boreholes 22-01 and 22-02.

One well screen was sealed in the overburden at borehole 22-02 to measure the groundwater level. The groundwater level was measured on July 14, 2022.

One sample of soil obtained from borehole 22-01 was sent to Paracel Laboratories Ltd. for basic chemical testing relating to corrosion of buried concrete and steel.

The borehole locations were selected by GEMTEC and positioned on site relative to existing features. The ground surface elevations at the borehole locations were determined using a precision GPS survey unit.

The fieldwork was supervised throughout by a member of our engineering staff who directed the drilling and excavating operations, logged the samples and boreholes, and carried out the in-situ testing. Following completion of the drilling, the soil samples were returned to our laboratory for examination by a geotechnical engineer and for laboratory testing. Selected soil samples were tested for water content, grain size distribution, Atterberg and shrinkage limits, oedometer consolidation testing and unconfined compressive strength.

Descriptions of the subsurface conditions logged in the boreholes are provided on the Record of Borehole Sheets in Appendix A. The results of the laboratory classification testing are provided on the Record of Borehole sheets and in Appendix B. The results of chemical testing completed on one soil sample are provided in Appendix C.

4.0 SUBSURFACE CONDITIONS

The borehole logs indicate the subsurface conditions at the specific test locations only. Boundaries between zones on the logs are often not distinct, but rather are transitional and have been interpreted. Subsurface conditions at locations other than the borehole locations may vary from the conditions encountered in the boreholes. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site.

The soil descriptions in this report are based on commonly accepted methods of classification and identification employed in geotechnical practice. Classification and identification of soil involves judgement and GEMTEC does not guarantee descriptions as exact, but infers accuracy to the extent that is common in current geotechnical practice.

The following presents an overview of the subsurface conditions encountered in the boreholes advanced during this investigation.

4.1 Topsoil

A layer of topsoil was encountered at the ground surface with a thickness of about 230 and 350 millimetres at boreholes 22-01 and 22-02, respectively.

4.2 Silty Clay

A native deposit of silty clay was encountered below the topsoil in the borehole locations. The upper portion of the silty clay has been weathered to a grey brown crust. The weathered crust extends to a depth of about 2.7 metres below the existing surface grade.

Standard penetration tests carried out in the weathered silty clay gave SPT 'N' values ranging from 1 to 7 blows per 0.3 metres of penetration, which based on our experience with silty clay in the Eastern Ontario region, reflect a stiff to very stiff consistency.

One grain size distribution test was undertaken on a selected sample of the weathered crust. The results are provided in Appendix B and are summarized in Table 4.1.

Table 4.1 – Summary of Grain Size Distribution Test (Weathered Crust)

Borehole ID	Sample Number	Sample Depth (metres)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
22-02	2	0.76 – 1.37	0.0	5	45	50

The results of Atterberg Limit testing carried out on two samples of the weathered crust are provided on the Plasticity Chart in Appendix B and are summarized in Table 4.2.

Table 4.2 – Summary of Atterberg Limit Testing (Silty Clay)

Borehole ID	Sample Number	Sample Depth (metres)	Water Content (%)	LL (%)	PL (%)	PI
22-01	3	1.5 – 2.1	44	37	16	21
22-02	2	0.7 – 1.3	29	36	17	19

The measured water content of three samples of the weathered silty clay crust ranges from about 25 to 44 percent.

A sample of the weathered crust was tested in our laboratory to determine the Shrinkage limits of the silty clay at the site. The testing was performed in general accordance with ASTM D4943 (which was discontinued in 2017 by the ASTM Sponsoring Committee responsible for the standard). The modified plasticity index (PI_m) was also calculated for samples of the clay using the following formula and the results of the Atterberg limits and grain size distribution testing described previously:

PI_m = PI x (% passing the 425 micrometre sieve / 100).

A summary of the test and calculation results is provided in Table 4.3.

Table 4.3 – Summary of Modified Plasticity Index

Borehole ID / Sample No.	Shrinkage Limit (%)	Plastic Limit (%)	Liquid Limit (%)	Plasticity Index (%)	Modified Plasticity Index (%)
22-01 / 3	–	16	37	21	20
22-02 / 2	14	17	36	19	18

The silty clay below weathered zone (and sand layer) is grey in colour. The grey silty clay was not fully penetrated but was proven to a depth of about 8.2 metres below the existing ground surface.

Standard penetration tests carried out in the grey silty clay gave SPT N values of weight of hammer per 0.3 metres of penetration. In-situ vane shear strength tests carried out in the silty clay gave undrained shear strengths generally ranging from about 20 to 25 kilopascals, which indicate a soft consistency.

An unconfined compressive strength (UCS) test was performed on a sample of the grey silty clay from borehole 22-02 at a depth of about 4.6 metres. The testing was performed in general accordance with ASTM D2166. A maximum stress of about 42 kilopascals was measured, which occurred at a strain of about 4.5 percent. The results of the UCS test are reasonably consistent with the in-situ measurements of undrained shear strength. The results of the testing are provided in Appendix B which includes photographs of the sample at failure.

The results of Atterberg Limit testing carried out on one sample of the grey silty clay are provided on the Plasticity Chart in Appendix B and are summarized in Table 4.4. The testing was performed in general accordance with ASTM D4318.

Table 4.4 – Summary of Atterberg Limit Testing (Grey Silty Clay)

Borehole ID	Sample Number	Sample Depth (metres)	Water Content (%)	LL (%)	PL (%)	PI
22-02	6	4.6 – 5.2	61	42	21	21

The measured water content of six samples of the unweathered silty clay was about 32 to 70 percent which in general exceeds the liquid limit of the soil.

One laboratory oedometer consolidation test was carried out on a Shelby tube sample from borehole 22-02. The results are summarized in Table 4.5. A plot of the variation in void ratio with applied stress from the consolidation test is presented in Appendix B.

Table 4.5 – Summary of Oedometer Testing

Borehole ID	Sample Depth (metres)	Estimated Past Preconsolidation Pressure, P_c', (kilopascals)	Existing Vertical Effective Stress, P_o' (kilopascals)	Initial Void Ratio, e_o	Recompression Index, C_r	Compression Index, C_c
22-02	4.9	105	34	1.8	0.03	1.15

4.3 Sand

A (relatively thin) layer of sand with trace gravel was encountered below the weathered silty clay crust with a thickness of about 200 millimetres at a depth of about 2.7 metres below the existing ground surface.

4.4 Groundwater Level

One monitoring well was installed in overburden at borehole 22-02 to measure the groundwater level. The response zone was sealed within the grey silty clay, refer to the record of borehole sheet for further details of the monitoring well. The observed groundwater level depth and elevation are summarized in Table 4.6.

The groundwater levels may be higher during wet periods of the year such as the early spring or following periods of precipitation.

Table 4.6 – Summary of Groundwater Levels

Borehole ID	Groundwater Depth (metres)	Groundwater Elevation (metres)	Date
22-02	1.6	99.6	July 14, 2022

4.5 Chemistry Relating to Corrosion

One sample of soil obtained from borehole 22-01 was sent to Paracel Laboratories for basic chemical testing relating to corrosion of buried concrete and steel. The results are provided in Appendix C and are summarized in Table 4.7 below.

Table 4.7 – Summary of Corrosion Testing

Parameter	Borehole 22-01 Sample No. 3
Chloride Content (µg/g)	42
Resistivity (Ohm.m)	23.9
pH	7.44
Sulphate Content (µg/g)	246

5.0 RECOMMENDATIONS

5.1 General

This section of the report provides engineering guidelines on the geotechnical design aspects of the project based on our interpretation of the borehole information and project requirements. It is stressed that the information in the following sections is provided for the guidance of the design engineers and is intended for this project only. 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 retained for this project include only the geotechnical aspects of the subsurface conditions at this site. The presence or implications of possible surface and/or subsurface contamination resulting from previous uses or activities of this site or adjacent properties, and/or resulting from the introduction onto the site from materials from off site sources are outside the terms of reference for this geotechnical report.

5.2 Excavation

The excavations for the proposed commercial development will be carried out through the topsoil, and into the weathered silty clay deposit. Although not encountered in the current investigation, fill material associated with the existing structures (i.e. foundation wall backfill etc.) is also likely to be encountered. The composition of the fill material in unknown at this time.

The sides of the excavations should be sloped in accordance with the requirements in Ontario Regulation 213/91 under the Occupational Health and Safety Act. According to the Act, the overburden soils at this site can be classified as Type 3 and, accordingly, allowance should be made for excavation side slopes of 1 horizontal to 1 vertical, or flatter, above the groundwater level. Careful inspection of the existing fill material should be carried out to determine the soil Type in this material.

Based on the measured groundwater elevations, excavation below the groundwater level as part of the development is not anticipated. Excavation of the native overburden deposits above the groundwater level should not present significant constraints.

The weathered silty clay crust deposit is sensitive to disturbance from ponded water, vibration and construction traffic. As such, it is suggested that final trimming to subgrade level be carried out using a hydraulic shovel equipped with a flat blade bucket. Allowance should be made to remove and replace any disturbed silty clay with compacted sand and gravel, such as that meeting OPSS Granular A or Granular B Type II, where required.

5.3 Excavation Next to Existing and Adjacent Building Foundations

The details of the foundations for the existing structure are not known to GEMTEC at this time. It is recommended that the foundations depths be determined/confirmed in advance of construction.

To prevent undermining of the existing building foundations, it is recommended that the bottom of the excavation for the proposed footings be located beyond a line extending down and out from the bottom edge of the existing and adjacent building foundations at 1 horizontal to 1 vertical, or flatter. If excavation is required within this zone, underpinning of the existing and adjacent foundations may be required. Details for underpinning could be provided upon request.

To avoid the issues described above, the underside of footing level should match the existing underside of footing level where the new foundation walls abut the existing foundation walls.

5.4 Groundwater Management

The groundwater level on July 14, 2022, was measured to be about 1.6 metres below ground surface in borehole 22-02.

A relatively thin sand layer was encountered within the silty clay deposits which may be water bearing. Any groundwater inflow into the excavation should be handled from within the excavation by pumping from filtered sumps. Suitable detention and filtration will be required before discharging the water to a sewer or ditch. The amount of water entering the excavation for the construction of the foundations at this site should not exceed 50,000 litres per day and therefore it is not anticipated that an Environmental Activity and Sector Registry (EASR) will be required.

5.5 Placement of Engineered Fill

In areas where the proposed founding level is above the level of the native soil, or where subexcavation of disturbed material is required below proposed founding level, imported granular material (engineered fill) should be used. The engineered fill should consist of granular material meeting Ontario Provincial Standard Specifications (OPSS) requirements for Granular B Type II and should be compacted in maximum 200 millimetre thick lifts to at least 95 percent of the material's standard Proctor maximum dry density.

In areas where groundwater inflow is encountered, pumping should be carried out from sumps in the excavation during placement of the engineered fill. To allow spread of load beneath the footings, the engineered fill should extend horizontally at least 0.3 metres beyond the footings and then down and out from the edges of the footings at 1 horizontal to 1 vertical, or flatter. The excavation for the building addition should be sized to accommodate this fill placement. Since the source of recycled material cannot be determined, it is suggested that, for environmental reasons, any granular materials used below founding level be composed of virgin material only. The engineered fill should be placed in accordance with the site grade raise restrictions, where applicable.

5.6 Grade Raise Restrictions

The site is underlain by deposits of grey silty clay which have, in general, a soft consistency. The placement of fill material across the site must be controlled so that the stress imposed by the fill material does not result in excessive consolidation of the grey silty clay deposits. The settlement response of the silty clay deposits due to the increase in stress caused by fill material is influenced by variables such as the existing effective overburden pressure, the past preconsolidation pressure for the silty clay, the compressibility characteristics of the silty clay, and the presence or absence of drainage paths, etc. It is well established that the settlement response of silty clay deposits can be significant when the stress increase is near or above the preconsolidation pressure.

For design purposes, the grade raise across the site should be restricted to about 0.6 metres, assuming that conventional earth fill (i.e. sand, silty sand) is used around the proposed building addition. If greater than 0.6 metres of grade raise is required, additional analysis should be carried out.

If records of design/construction for the existing structure are available these may assist in further assessment of the grade raise restrictions for the site and should be provided to GEMTEC for review.

5.7 Foundation Design

In general, the weathered silty clay deposits are considered suitable to support the proposed building addition founded on conventional strip or pad footing foundations. All organic material, topsoil, fill material, and loose or water softened soils should be removed from within the proposed footing areas.

The bearing pressures for strip or pad footing foundations at this site are based on the necessity to limit the stress increase on the softer grey silty clay layer below the weathered crust to an acceptable level so that foundation settlements will not be excessive. Four important parameters in calculating the stress increase on the grey silty clay beneath the weathered crust are:

- The thickness of the soil beneath the base of the foundation and the surface of the softer silty clay;
- The size, type (i.e. pad or strip) and loading of the foundation;
- The amount of surcharge (fill, etc.) in the vicinity of the foundation; and
- The amount of post-development groundwater lowering at the site.

From a spread footing design perspective, it is preferable to maximize the vertical separation between the underside of the footings and the surface of the softer, grey silty clay to distribute the foundation loads onto the softer, grey silty clay at depth. This can be achieved by founding the structure as high as practical within the soil profile and minimizing the amount of fill (surcharge) on the site; noting that the proposed foundation position may also be affected by the configuration of the existing structure.

Based on information provided to us by DS Studio, it is our understanding that the finished floor elevation for the proposed building addition will be at an elevation of 101.7 metres. We have based our preliminary design on an underside of footing elevation of about 100.2 metres. Preliminary geotechnical details for this foundation scenario are presented in Table 5.1 below.

Table 5.1 – Preliminary Foundation Bearing Pressures

Type of Footing	Maximum Size of Footing (metres)	Net Geotechnical Reaction at Serviceability Limit State (SLS)[1] (kilopascals)	Factored Net Geotechnical Resistance at Ultimate Limit State (ULS) (kilopascals)
Exterior Strip	1.0	75	125
Interior Pad	1.0 square	75	125

Notes:
1. The total settlement of the foundation at SLS should be less than 25 millimetres.

The settlement of the addition will be differential relative to the existing structure, thus provisions should be made in the structural design to accommodate this.

5.8 Frost Protection of Foundations

All exterior footings should be provided with at least 1.5 metres of earth cover for frost protection purposes. Isolated (unheated) footings that are located in areas that are to be cleared of snow should be provided with at least 1.8 metres of earth cover for frost protection purposes. Alternatively, the required frost protection could be provided by means of a combination of earth cover and extruded polystyrene insulation. An insulation detail could be provided upon request.

If the foundation and/or slab on grade are insulated in a manner that will reduce heat flow to the surrounding soil, the foundation depth shall conform to that required for foundations for an unheated space.

5.9 Foundation Wall Backfill and Drainage

The native deposits at this site are frost susceptible and should not be used as backfill against foundations. To avoid frost adhesion and possible heaving, the foundations should be backfilled with imported, free-draining, non-frost susceptible granular material such as that meeting the requirements of OPSS Granular A, or Granular B Type I or II.

Where the backfill will ultimately support areas of hard surfacing (pavement, sidewalks or other similar surfaces), the backfill should be placed in maximum 200 millimetre thick lifts and should be compacted to at least 95 percent of the material's standard Proctor maximum dry density value using suitable vibratory compaction equipment. Light walk behind compaction equipment should be used next to the foundation walls to avoid excessive compaction induced stress on the foundation walls.

Where future landscaped areas will exist next to the proposed structures and if some settlement of the backfill is acceptable, the backfill could be compacted to at least 90 percent of the material's standard Proctor maximum dry density value. Where areas of hard surfacing (concrete, sidewalks, pavement, etc.) abut the proposed structures, a gradual transition should be provided between those areas of hard surfacing underlain by non-frost susceptible granular wall backfill and those areas underlain by existing frost susceptible fill material to reduce the effects of differential frost heaving. It is suggested that granular frost tapers be constructed from 1.5 metres below finished grade to the underside of the granular subbase material for the hard surfaced areas. The frost tapers should be sloped at 1 horizontal to 1 vertical, or flatter. Further, we recommend that downspouts outlet in such a way as to prevent saturation of soils below hard surfaced areas.

The frost susceptible native soils could be considered for foundation wall backfill purposes in soft landscaped areas provided that a suitable bond break is applied to the surface of the foundations to prevent frost jacking. A suitable bond break could consist of at least 2 layers of 6 MIL polyethylene sheeting or a proprietary plastic drainage system. It is also pointed out that the native soils at this site can be impacted by changes in moisture content and this could affect the ability to compact this material to the required density.

Perimeter foundation drainage is not considered necessary for a slab on grade structure provided that the floor slab level is above the finished exterior ground surface level. Existing foundation drainage systems associated with the existing structure should be maintained.

5.10 Slab on Grade Support

The topsoil and fill material are not considered suitable for support of the slab on grade. To prevent long term settlement of the floor slab, all organic material and any fill should be removed from below the proposed slab to expose the native silty clay deposits.

The grade within the proposed building could then be raised, where necessary, with material meeting OPSS requirements for Granular A and Granular B Type I or II. The granular base for the proposed slab on grade should consist of at least 150 millimetres of OPSS Granular A.

OPSS documents allow recycled asphaltic concrete and concrete to be used in Granular A. Since the source of recycled material cannot be determined, it is suggested that any granular materials used beneath the floor slab be composed of virgin material only, for environmental reasons.

All imported granular materials placed below the proposed floor slab should be compacted in maximum 200 millimetre thick lifts to at least 95 percent of the material’s standard Proctor maximum dry density value.

Underfloor drainage is not considered necessary provided that the floor slab levels are above the finished exterior ground surface level.

If any areas of the buildings are to remain unheated during the winter period, thermal protection of the slab on grade may be required. Further details on the insulation requirements could be provided, if necessary.

The floor slabs should be wet cured to minimize shrinkage cracking and slab curling. The slab should be saw cut to about 1/3 the thickness of the slab as soon as curing of the concrete permits, in order to minimize shrinkage cracks.

Proper moisture protection with a vapour retarder should be used for floor slabs where the floor will be covered by moisture sensitive flooring material or where moisture sensitive equipment, products or environments will exist. The “Guide for Concrete Floor and Slab Construction”, ACI 302.1R-04 should be considered for the design and construction of vapour retarders below the floor slabs.

5.11 Proposed Services

Details of the proposed services to be installed as part of the works were not available to GEMTEC. As such relatively generic guidelines are provided only.

5.11.1 Excavation

In the overburden, the excavation for flexible service pipes should be in accordance with Ontario Provincial Standard Drawing (OPSD) 802.010 for Type 3 soil. The excavation for rigid service pipes should be in accordance with OPSD 802.031 for Type 3 soil. The sides of the excavations within overburden soils should be sloped in accordance with the requirements in Ontario Regulation 213/91 under the Occupational Health and Safety Act. According to the Act, the soils at this site can be classified as Type 3 soils. Therefore, for design purposes, allowance should be made for 1 horizontal to 1 vertical, or flatter, excavation slopes. As an alternative or where space constraints dictate, the service installations could be carried out within a tightly fitting, braced steel trench box, which is specifically designed for this purpose.

Groundwater seepage into excavations is expected and should be controlled, as necessary, by pumping from within the excavations. It is not expected that short term pumping during excavation will have a significant effect on nearby structures and services.

5.11.2 Pipe Bedding

The bedding for service pipes should be in accordance with OPSD 802.010 and 802.031 for flexible and rigid pipes in Type 3 soils, respectively. The bedding for service pipes should consist of at least 150 millimetres of crushed stone meeting OPSS requirements for Granular A.

Cover material, from spring line to at least 300 millimetres above the top of the pipes, should consist of granular material, such as that meeting OPSS Granular A.

In areas where the subsoil is disturbed or where unsuitable material (such as fill material) exists below the pipe subgrade level, the disturbed/unsuitable material should be removed and replaced with a subbedding layer of compacted granular material, such as that meeting OPSS Granular B Type I or II. To provide adequate support for the pipes in the long term in areas where subexcavation of material is required below design subgrade level, the excavations should be sized to allow a 1 horizontal to 1 vertical spread of granular material down and out from the bottom of the pipes.

Cover material, from pipe spring line to at least 300 millimetres above the top of the pipe, should consist of granular material, such as OPSS Granular A. The granular bedding and subbedding materials should be compacted in maximum 200 millimetre thick lifts to at least 95 percent of the standard Proctor dry density value.

The use of clear crushed stone as a bedding, subbedding or cover material should not be permitted on this project.

5.11.3 Trench Backfill

In areas where the service trench will be located below or in close proximity to existing or future areas of hard surfacing (pavement, sidewalk, etc.), acceptable native materials should be used as backfill between the roadway subgrade level and the depth of seasonal frost penetration in order to reduce the potential for differential frost heaving between the area over the trench and the adjacent hard surfaced area. The depth of frost penetration in exposed areas can normally be taken as 1.8 metres below finished grade. Where native backfill is used, it should match the native materials exposed on the trench walls. Backfill below the zone of seasonal frost penetration could consist of either acceptable native material or imported granular material conforming to OPSS Granular B Type I or II.

To minimize future settlement of the backfill and achieve an acceptable subgrade for the parking areas, sidewalks, etc., the trench backfill should be compacted in maximum 300 millimetre thick lifts to at least 95 percent of the material's standard Proctor dry density value. The specified density for compaction of the backfill materials may be reduced where the trench backfill is not located below or in close proximity to existing or future areas of hard surfacing and/or structures.

5.12 Roadway Construction

It is anticipated that interior access roads/at grade parking areas will be included in the proposed works, although no details were available at the time of preparing this report.

Truck traffic should be avoided on the native soil subgrade or the trench backfill within the roadways/parking lot areas especially under wet conditions.

5.12.1 Subgrade Preparation

In preparation for access roadway/parking lot construction at this site, all surficial topsoil, and any soft, wet or deleterious materials should be removed from the proposed roadway areas.

Prior to placing granular material for the roads and parking lots, the exposed subgrade should be inspected and approved by geotechnical personnel. The exposed subgrade should be proof rolled with a suitably sized vibratory steel drum roller under dry conditions. Any soft areas should be subexcavated and replaced with suitable (dry) earth borrow that is frost compatible with the materials exposed on the sides of the area of subexcavation.

In areas where it will be necessary to raise the roadway/parking lot grades at this site, material which meets OPSS specifications for Select Subgrade Material, Earth Borrow or well shattered and graded rock fill material may be used.

The Select Subgrade material or Earth Borrow should be placed in maximum 300 millimetre thick lifts and compacted to at least 95 percent of the material's standard Proctor maximum dry density value using vibratory compaction equipment.

5.12.2 Pavement Structure

For the parking areas to be used by light vehicles (cars, etc.), the following minimum pavement structure is recommended:

- 80 millimetres of hot mix asphaltic concrete (Two 40 millimetre lifts of Superpave 12.5), over
- 150 millimetres of OPSS Granular A base, over
- 300 millimetres of OPSS Granular B, Type II subbase

For parking areas and access roadways to be used by heavy truck traffic, the suggested minimum pavement structure is:

- 100 millimetres of hot mix asphaltic concrete (40 millimetres of Superpave 12.5 over 60 millimetres of Superpave 19.0), over
- 150 millimetres of OPSS Granular A base, over
- 450 millimetres of OPSS Granular B, Type II subbase

The above pavement structures assume that the access roadway and parking lot subgrade surfaces are prepared as described in this report. If the subgrade surfaces become disturbed or wetted due to construction operations or precipitation, the granular subbase thicknesses given above may not be adequate and it may be necessary to increase the thickness of the subbase and/or to incorporate a woven geotextile separator between the subgrade surfaces and the granular subbase material. The adequacy of the design pavement thicknesses should be assessed by geotechnical personnel as the details of the proposed developed are established, and at the time of construction based on the observed conditions.

If the granular pavement materials are to be used by construction traffic, it may be necessary to increase the thickness of the granular subbase layer, install a woven geotextile separator between the roadway subgrade surface and the granular subbase material, or a combination of both, to prevent pumping and disturbance to the subbase material. The contractor should be made responsible for their construction access.

5.12.3 Asphalt Cement Type

Performance grade PG 58-34 asphalt cement should be specified for Superpave asphaltic concrete mixes.

5.12.4 Pavement Transitions

The following is suggested to improve the performance of the joint between the new and the existing pavements:

- Neatly saw cut the existing asphaltic concrete;
- Remove the asphaltic concrete and slope the bottom of the excavation within the existing granular base and subbase at 1 horizontal to 1 vertical, or flatter, to avoid undermining the existing asphaltic concrete.
- To avoid cracking of the asphaltic concrete due to an abrupt change in the thickness of the roadway granular materials where new pavement areas join with the existing pavements, the granular depths should taper up or down at 5 horizontal to 1 vertical, or flatter, to match the existing pavement structure.
- Remove (mill off) 40 to 50 millimetres of the existing asphaltic concrete to a distance of 300 millimetres at the joint and tack coat the asphaltic concrete at the joint in accordance with the requirements in OPSS 310.

5.12.5 Pavement Drainage

Adequate drainage of the pavement granular materials and subgrade is important for the long term performance of the pavement at this site. The subgrade surfaces should be crowned and shaped to drain to the ditches and/or catch basins to promote drainage of the pavement granular materials.

Catch basins should be equipped with minimum 3 metre long stub drains extending in two directions at the subgrade level.

5.13 Corrosion of Buried Concrete and Steel

According to Canadian Standards Association (CSA) "Concrete Materials and Methods of Concrete Construction", the concentration of sulphate in the soil sample recovered from borehole 22-01 can be classified as low.

For low exposure conditions, any concrete that will be in contact with the native soil or groundwater could be batched with General Use (GU) type cement. The effects of freeze thaw in the presence of de-icing chemical (sodium chloride) near the buildings should be considered in selecting the air entrainment and the concrete mix proportions for any exposed concrete.

Based on the resistivity and pH of the soil samples tested the soil can be generally classified as non aggressive to slightly aggressive toward unprotected steel. It is noted that the corrosivity of the soil could vary throughout the year due to the application sodium chloride for de-icing.

5.14 Sensitive Marine Clay – Effects of Trees

The site is underlain by silty clay, a material which is known to be susceptible to shrinkage with a change/reduction in moisture content. Research by the Institute for Research in Construction (formerly the Division of Building Research) of the National Research Council of Canada has shown that trees can cause a reduction of moisture content in the silty clays in the Ottawa area, which can result in significant settlement/damage to nearby buildings supported on shallow foundations, or hard surfaced areas. Therefore, deciduous tree planting should be carried in accordance with the guidelines identified in the City of Ottawa document titled: "Tree Planting in Sensitive Marine Clay Soils – 2017 Guidelines".

The City of Ottawa Tree Planting Guidelines indicates that sensitive marine clay soils with a modified plasticity index of less than 40 percent are considered to have a low/medium potential for soil volume change. Clay soils with a modified plasticity index that exceeds 40 percent are considered to have a high potential for soil volume change.

The modified plasticity index of the samples of weathered crust provided in Table 4.3 are about 18 and 20 percent. As such, the potential for soil volume change, as defined by the City of Ottawa, is low/medium.

In accordance with the City of Ottawa Tree Planting Guidelines, tree planting restrictions apply where clay soils with low/medium potential for volume change are present between the underside of footing and a depth of 3.5 metres below finished grade (refer to the City of Ottawa document titled: "Tree Planting in Sensitive Marine Soils - 2017 Guidelines") – as is likely the case at this site.

According to the City of Ottawa 2017 Tree Planting Guidelines, the tree to foundation setbacks within the development can be reduced to 4.5 metres for small to medium sized trees (i.e., trees with a mature height of less than 14 metres) with further information and recommendations on planting trees near foundations provided in the City of Ottawa Tree Planting in Sensitive Marine Clay Soils – 2017 Guidelines.

6.0 ADDITIONAL CONSIDERATIONS

6.1 Effects of Construction Induced Vibration

Some of the construction operations (such as granular material compaction, excavation, etc.) will cause ground vibration on and off of the site. The vibrations will attenuate with distance from the source, but may be felt at nearby structures. The magnitude of the vibrations will be much less than that required to cause damage to the nearby structures or services in good condition.

6.2 Monitoring Well Abandonment

Monitoring well installed as part of this investigation should be decommissioned by a licensed well technician. The well abandonment could be carried out in advance of or during construction.

6.3 Design Review and Construction Observation

Very few details of the proposed development were available to GEMTEC at the time of this report and therefore aspects of this report are considered preliminary – where noted. As the design is progressed the details should be provided to GEMTEC. In addition, any details of the existing structure (including for instance records of previous geotechnical investigation and reporting or construction records) should be provided to GEMTEC. Where necessary this report should be revised / updated accordingly based on the additional information.

The engagement of the services of the geotechnical consultant during construction is recommended to confirm that the subsurface conditions throughout the proposed excavations do not materially differ from those given in the report and that the construction activities do not adversely affect the intent of the design. The subgrade surfaces for the buildings, services, and access roadway/parking areas should be inspected by experienced geotechnical personnel to ensure that suitable materials have been reached and properly prepared. The placing and compaction of earth fill and imported granular materials should be inspected to ensure that the materials used conform to the grading and compaction specifications.

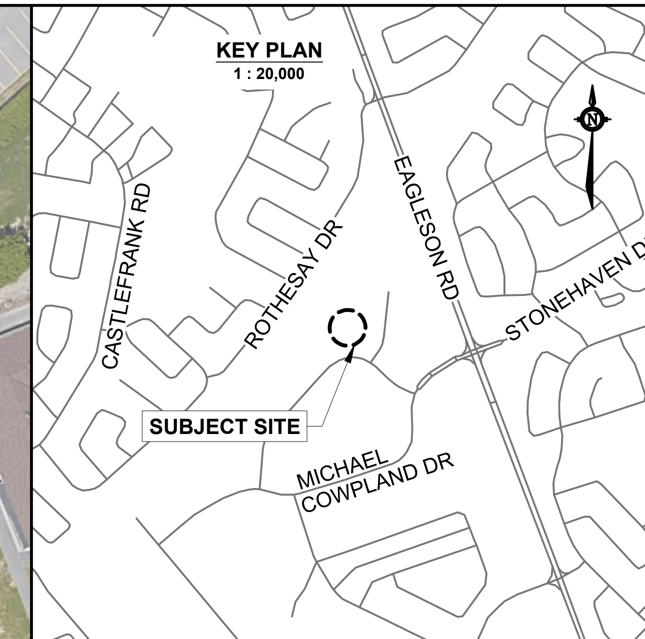
7.0 CLOSURE

We trust this report provides sufficient information for your present purposes. If you have any questions concerning this report, please do not hesitate to contact our office.

Pawandeep Singh, M.Eng.
Geotechnical Scientist

Alex Meacoe, P.Eng.
Senior Geotechnical Engineer

Brent Wiebe, P.Eng.
VP Operation - Ontario



LEGEND

- BH # — BOREHOLE ID
- XX.XX — GROUND SURFACE ELEVATION, IN METRES GEODETIC DATUM
- BOREHOLE LOCATION (current investigation by GEMTEC)
- APPROXIMATE PROPOSED ADDITION LOCATION
- APPROXIMATE PROPERTY BOUNDARY

SCALE
1:1000
0 20 40 60m

DRAWING	SITE PLAN
CLIENT	DS STUDIO
PROJECT	GEOTECHNICAL INVESTIGATION PROPOSED BUILDING ADDITION 100 TERENCE MATTHEWS CRESCENT OTTAWA, ONTARIO
DRAWN BY: S.L.	CHECKED BY: W.A.M.
PROJECT NO.: 101873.001	REVISION NO.: 0
DATE: AUGUST, 2022	FIGURE NO.: FIGURE 1

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APPENDIX A

Records of Borehole Logs
List of Abbreviations and Symbols
Borehole 22-01 and 22-02

Report to: DS Studio
Project: 101873.001 (October 6, 2022)

RECORD OF BOREHOLE 22-01

CLIENT: DS Studio
PROJECT: Geotechnical Investigation, Proposed Building Addition, 100 Terence Matthews Crescent, Ottawa, Ontario
JOB#: 101873.001
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jul 8 2022

BORING METHOD: Power Auger, Hollow Stem Auger (210mm OD)

SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)
Ground Surface	101.59
TOPSOIL	101.36 / 0.23
Stiff to very stiff, grey brown SILTY CLAY (WEATHERED CRUST)	98.90 / 2.69
Brown SAND, trace gravel	98.70 / 2.89
Soft, grey SILTY CLAY	93.36 / 8.23
END OF BOREHOLE	

SAMPLE NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m
1	SS	280	7
2	SS	255	4
3	SS	455	2
4	SS	480	2
5	SS	610	WH
6	TO	610	PH
7	SS	610	WH
8	SS	610	WH

Legend: ● PENETRATION RESISTANCE (N), BLOWS/0.3m; ▲ DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED; WATER CONTENT, %: W_P — W — W_L. Scale: 10 20 30 40 50 60 70 80 90

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION: Backfilled with Auger Cuttings

GEMTEC Consulting Engineers and Scientists

LOGGED: PS
CHECKED: WAM

GEO - BOREHOLE LOG 101873.001 GINT BH LOGS.GPJ GEMTEC 2018.GDT 8/30/22

RECORD OF BOREHOLE 22-02

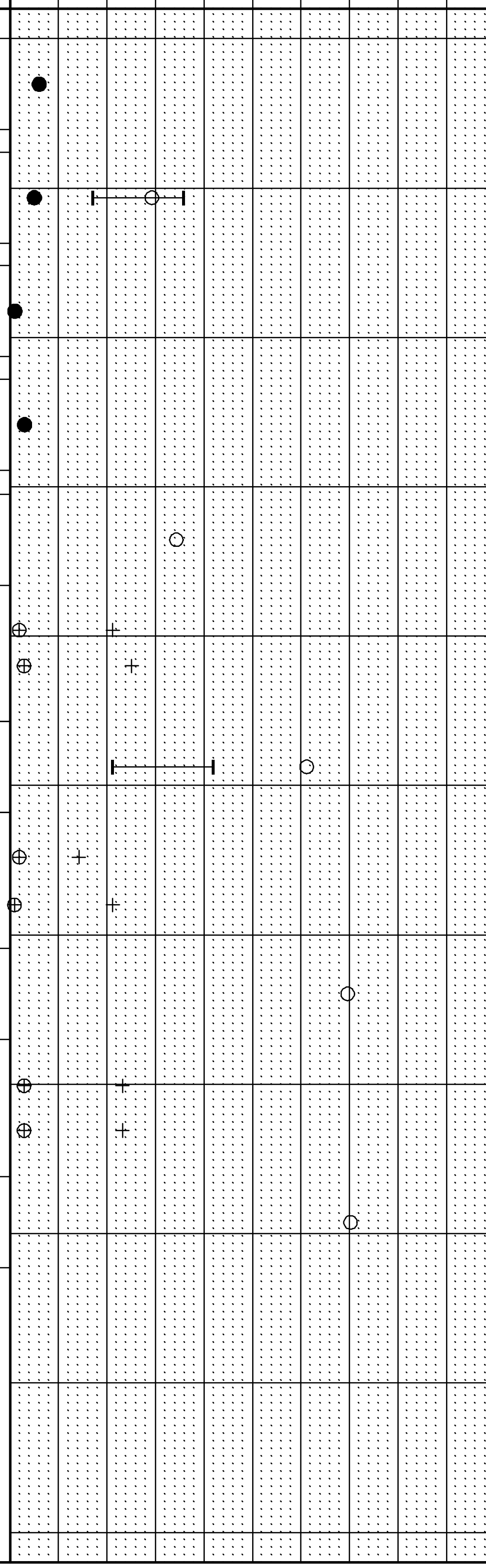
CLIENT: DS Studio
PROJECT: Geotechnical Investigation, Proposed Building Addition, 100 Terence Matthews Crescent, Ottawa, Ontario
JOB#: 101873.001
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Jul 8 2022

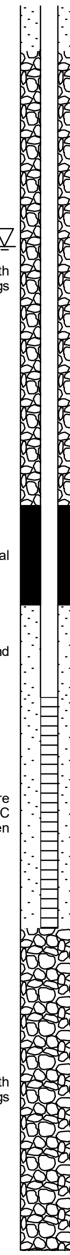
BORING METHOD: Power Auger — Hollow Stem Auger (210mm OD)

SOIL PROFILE – DESCRIPTION	ELEV. (m) / DEPTH (m)	SAMPLE NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	ADDITIONAL LAB. TESTING
Ground Surface	101.25					
TOPSOIL	100.90 / 0.35	1	SS	355	6	
Stiff to very stiff, grey brown SILTY CLAY (WEATHERED CRUST)		2	SS	510	5	
		3	SS	0	1	
	98.56 / 2.69	4	SS	255	3	
Brown SAND, trace gravel	98.36 / 2.89					
Soft to firm, grey SILTY CLAY		5	SS	610	WH	
		6	TO	610	PH	C UC
		7	SS	610	WH	
	93.02 / 8.23	8	SS	610	WH	
END OF BOREHOLE						

PENETRATION RESISTANCE (N), BLOWS/0.3m — SHEAR STRENGTH (Cu), kPA: + NATURAL ⊕ REMOULDED — DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m — WATER CONTENT, % (W_P, W, W_L)



PIEZOMETER OR STANDPIPE INSTALLATION



GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
22/07/14	1.6 ∇	99.7

GEMTEC Consulting Engineers and Scientists

LOGGED: PS
CHECKED: WAM

ABBREVIATIONS AND TERMINOLOGY USED ON RECORDS OF BOREHOLES AND TEST PITS

SAMPLE TYPES	
AS	Auger sample
CA	Casing sample
CS	Chunk sample
BS	Borros piston sample
GS	Grab sample
MS	Manual sample
RC	Rock core
SS	Split spoon sampler
ST	Slotted tube
TO	Thin-walled open shelby tube
TP	Thin-walled piston shelby tube
WS	Wash sample

SOIL TESTS	
w	Water content
PL, w_p	Plastic limit
LL, w_L	Liquid limit
C	Consolidation (oedometer) test
D_R	Relative density
DS	Direct shear test
G_S	Specific gravity
M	Sieve analysis for particle size
MH	Combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	Organic content test
UC	Unconfined compression test
γ	Unit weight

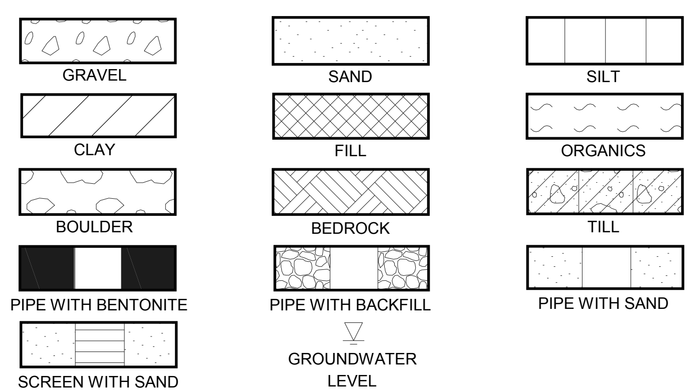
PENETRATION RESISTANCE

Standard Penetration Resistance, N
The number of blows by a 63.5 kg (140 lb) hammer dropped 760 millimetres (30 in.) required to drive a 50 mm split spoon sampler for a distance of 300 mm (12 in.). For split spoon samples where less than 300 mm of penetration was achieved, the number of blows is reported over the sampler penetration in mm.

Dynamic Penetration Resistance
The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive a 50 mm (2 in.) diameter 60° cone attached to 'A' size drill rods for a distance of 300 mm (12 in.).

WH	Sampler advanced by static weight of hammer and drill rods
WR	Sampler advanced by static weight of drill rods
PH	Sampler advanced by hydraulic pressure from drill rig
PM	Sampler advanced by manual pressure

COHESIONLESS SOIL Compactness		COHESIVE SOIL Consistency	
SPT N-Values	Description	Cu, kPa	Description
0-4	Very Loose	0-12	Very Soft
4-10	Loose	12-25	Soft
10-30	Compact	25-50	Firm
30-50	Dense	50-100	Stiff
>50	Very Dense	100-200	Very Stiff
		>200	Hard



GRAIN SIZE

Scale: 0.01, 0.1, 1.0, 10, 100, 1000mm

SILT CLAY	SAND – Fine	SAND – Medium	SAND – Coarse	GRAVEL	COBBLE	BOULDER
< 0.08	0.08 – 0.4	0.4 – 2	2 – 5	5 – 80	80 – 200	> 200

DESCRIPTIVE TERMINOLOGY

(Based on the CANFEM 4th Edition)

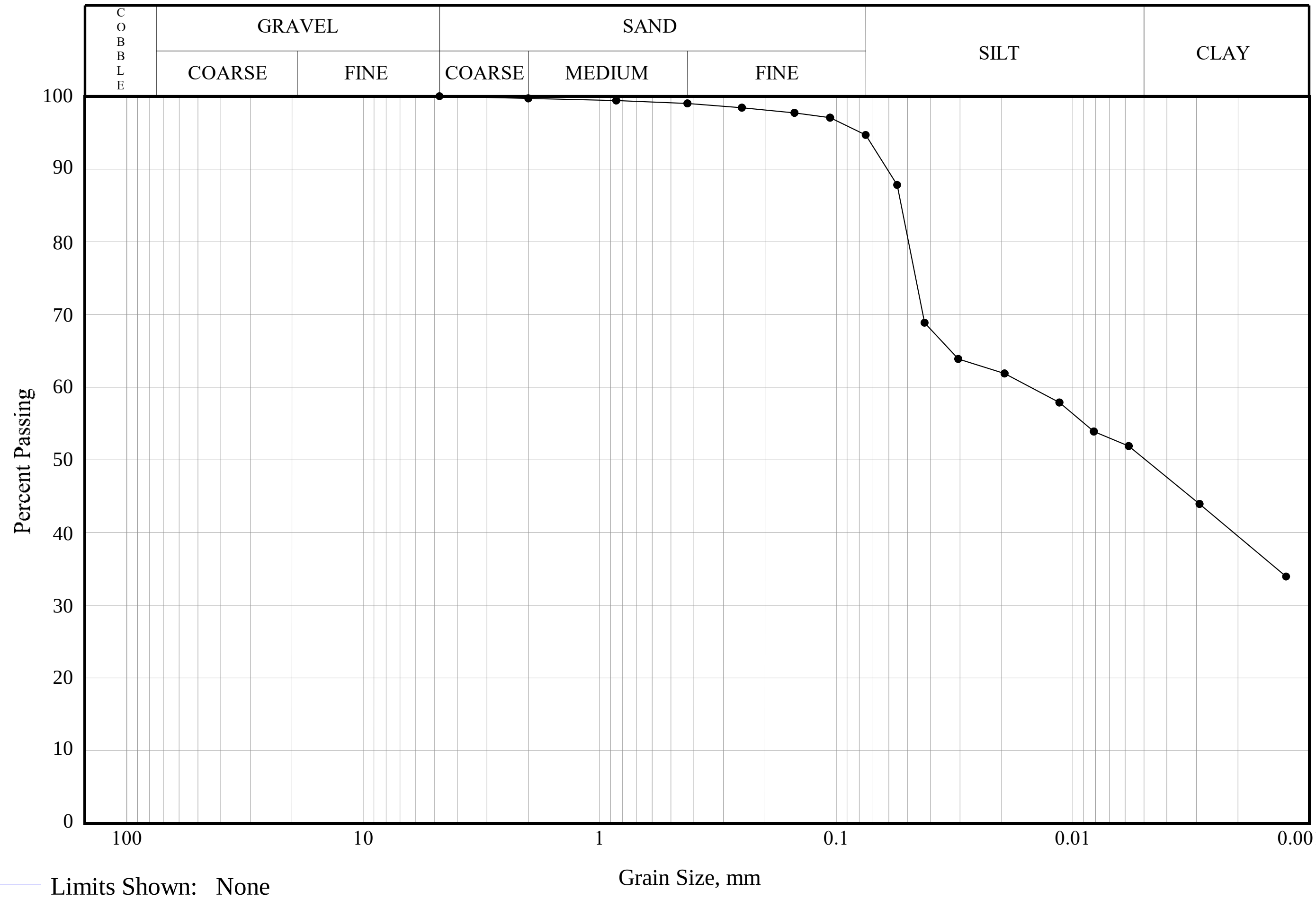
0 – 10	10 – 20	20 – 35	35
TRACE	SOME	ADJECTIVE	noun > 35% and main fraction
trace clay, etc	some gravel, etc.	silty, etc.	sand and gravel, etc.

APPENDIX B

Laboratory Test Results

Report to: DS Studio
Project: 101873.001 (October 6, 2022)

GEMTEC Consulting Engineers and Scientists	Client: DS Studio	Soils Grading Chart (LS-702/ ASTM D-422)
	Project: Geotechnical Investigation, Proposed Building Addition,	
	Project #: 101873001	

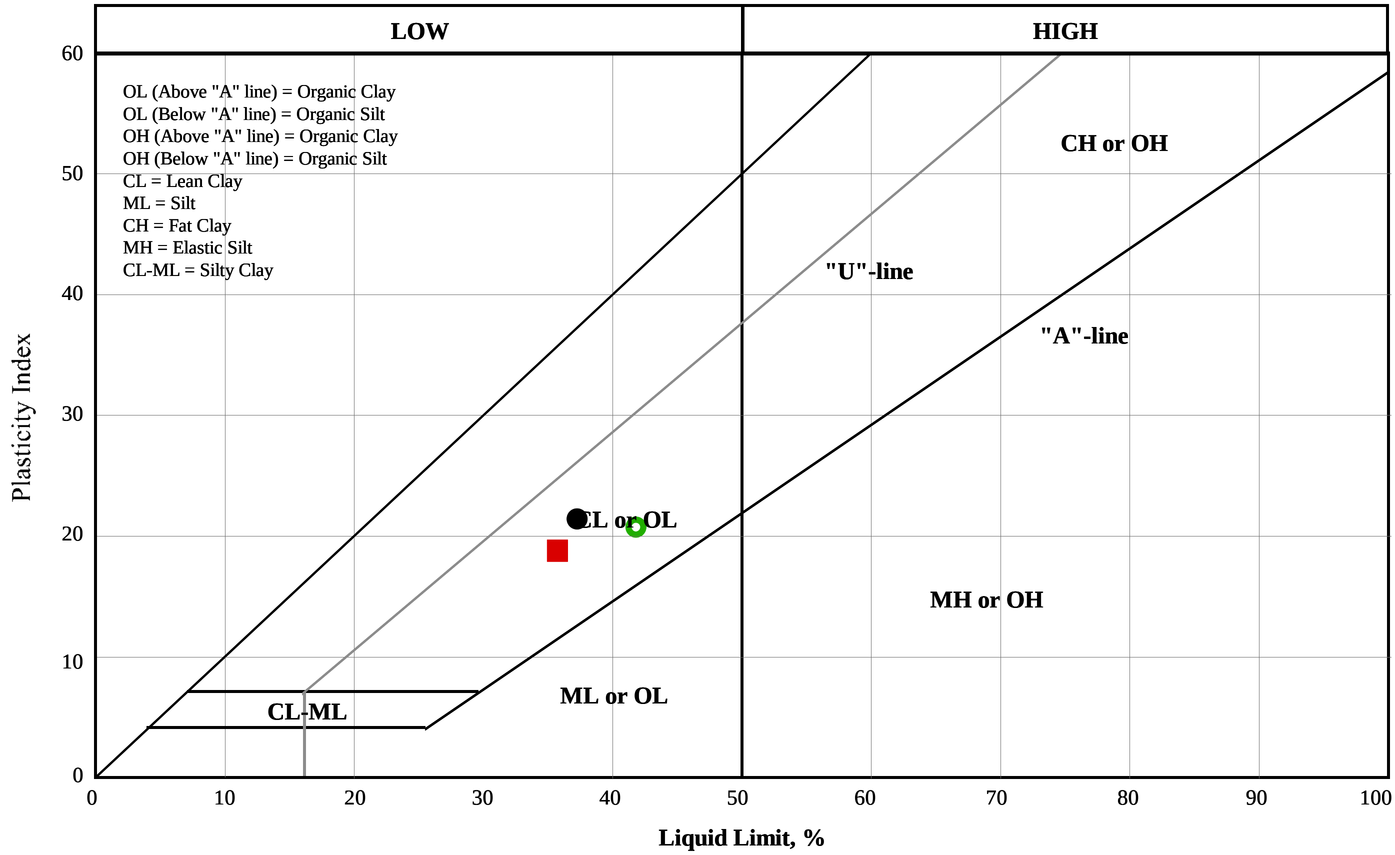


Limits Shown: None

Line Symbol	Sample	Borehole/ Test Pit	Sample Number	Depth	% Cob.+ Gravel	% Sand	% Silt	% Clay
—●—	WEATHERED CRUST	22-02	2	0.76-1.37	0.0	5.3	44.5	50.2

Line Symbol	CanFEM Classification	USCS Symbol	D_{10}	D_{15}	D_{30}	D_{50}	D_{60}	D_{85}	% 5-75µm
—●—	Clay and silt , trace sand	CL	---	---	---	0.00	0.02	0.05	44.5

GEMTEC Consulting Engineers and Scientists	Client: DS Studio	Plasticity Chart (D4318)
	Project: Geotechnical Investigation, Proposed Building Addition,	
	Project #: 101873001	



Symbol	Borehole /Test Pit	Sample Number	Depth	Liquid Limit	Plastic Limit	Plasticity Index	Non-Plastic	Moisture Content, %
●	22-01	3	1.52-2.13	37.2	15.8	21.4	☐	43.99
■	22-02	2	0.76-1.37	35.7	17.0	18.8	☐	29.26
○	22-02	ST 6	4.57-5.18	41.8	21.1	20.7	☐	61.22

Note: More information available upon request

Shrinkage Limit

ASTM D4943

Volume of Shrinkage Dish		
Mass of Glass Plate (g):	20.72	20.84
Mass of Shrinkage Dish (g) (m):	20.79	20.92
Mass of Shrinkage Dish and Grease(g) (m):	37.35	37.35
Mass of Shrinkage Dish, Plate, Grease and Water (g):	75.20	75.52
Mass of Water (g):	17.13	17.33
Volume of Shrinkage Dish:	17.00	17.00

Test Specimen

Specimen Dish:	SL1	SL2
Mass of Shrinakge Dish, m (g):	20.72	20.84
Mass of Shrinkage Dish and Grease, m_{dxg} (g):	20.79	20.93
Mass of Shrinkage Dish and Wet Soil, m_w (g):	51.2	52.56
Mass of Shrinkage Dish and Dry Soil, m_d (g):	42.61	43.63
Mass of Wax-Coated Soil in Air, m_{sxa} (g):	22.54	23.46
Mass of Wax-Coated Soil in Water, m_{sxw} (g):	10.5	11.1

Calculated Shrinkage Limit

Specimen Dish:	SL1	SL2
Mass of Dry Soil, m_s (g):	21.89	22.79
Water Content of Soil when Placed in Dish, w (%):	39.24	39.18
Mass of Water Displaced by Wax-Coated Soil, m_{wsx} (g):	12.04	12.36
Volume of Dry Soil and Wax, V_{dx} (cm^3):	12.04	12.36
Mass of Wax, m_x (g):	0.65	0.67
Volume of Wax, V_x (cm^3):	0.72	0.74
Volume of Dry Soil, V_d (cm^3):	11.32	11.62
Shrinkage Limit, SL:	12.69	14.99
Average Shrinkage Limit, $Sl_{avg.}$:	13.84	

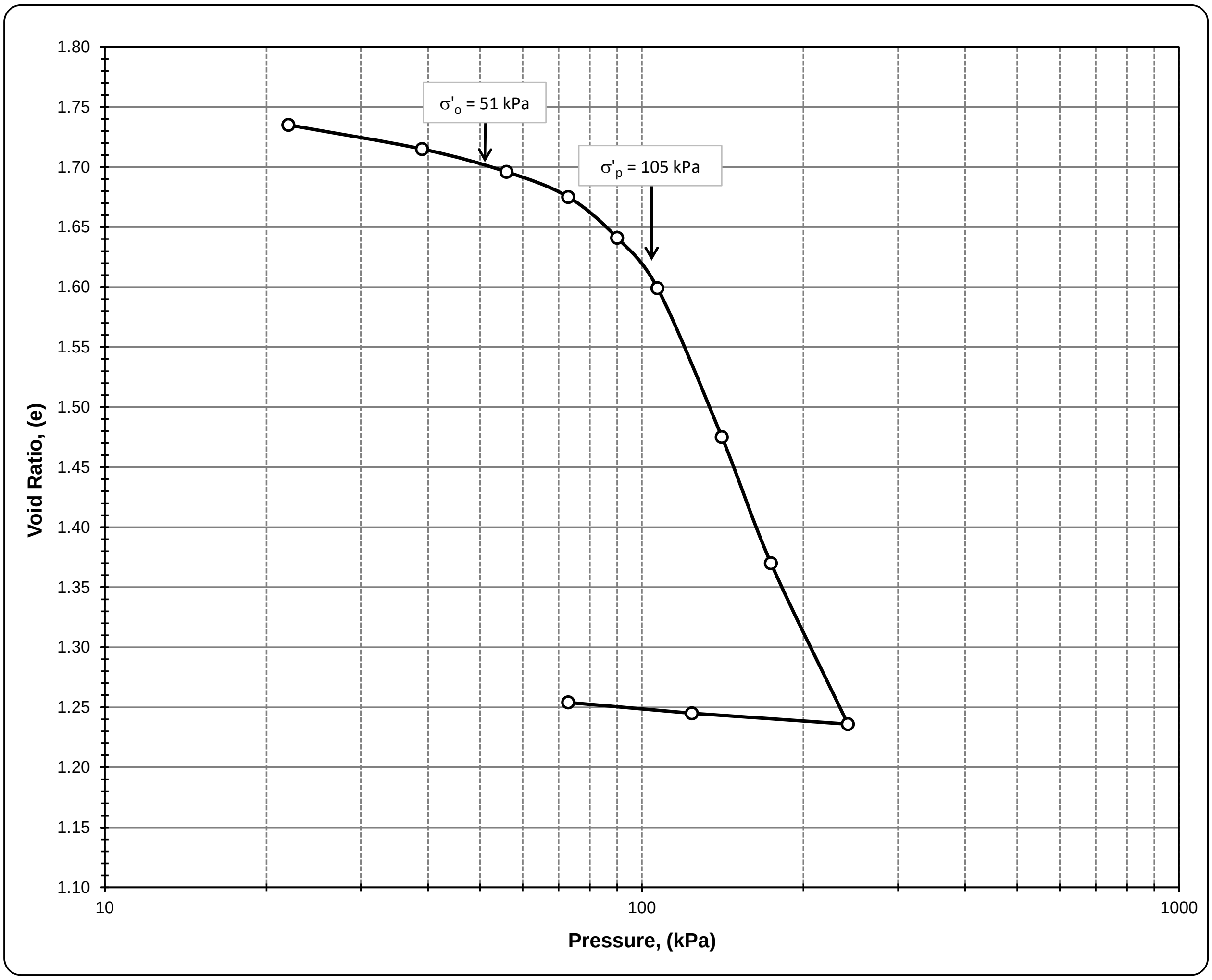
Specific Gravity of Wax = 0.908 at15.5°C

Specific Gravity of Wax = 0.900 at 20°C

Density of Water (g/cm^3) = 1.000 (g/cm^3)

Project No.: 101873.001	**Tested By:** KN/GK
Project Name:	**Checked By:**
Date Tested: July 15,2022	**Sample No:** 22-02 SA 2
Sample Date:	**Source:**
Remarks:	**Depth:** 2'6"-4'6"

CONSOLIDATION ANALYSIS



Borehole	Sample	Depth (m)
22-02	6	4.9

Determined Properties:

W	64	percent
e_o	1.77	

Test Results:

C_r	0.03	
C_c	1.15	
σ'_p	105	kPa

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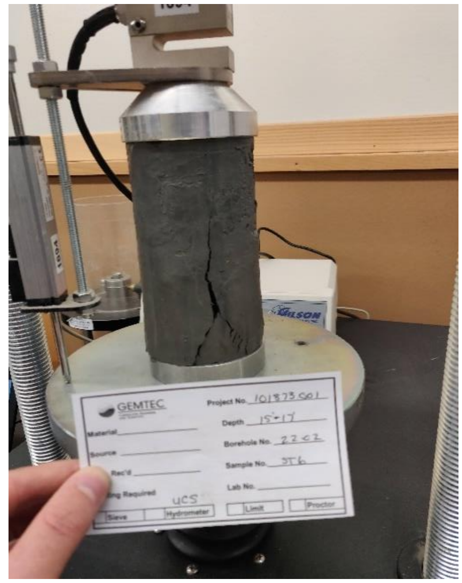
Date: Aug 2022
Project: 101873.001

UNCONFINED COMPRESSION TEST (ASTM D2166)	FIGURE 1

Project Number	101873.001
Project Description	100 Tarence/Matthers
Client	DS Studio
Date Tested	22/08/02
Borehole Number	BH22-02 ST6
Sample Numner	ST6
Sample Depth	4.57 to 5.18
Sample Description	Grey Si Cl

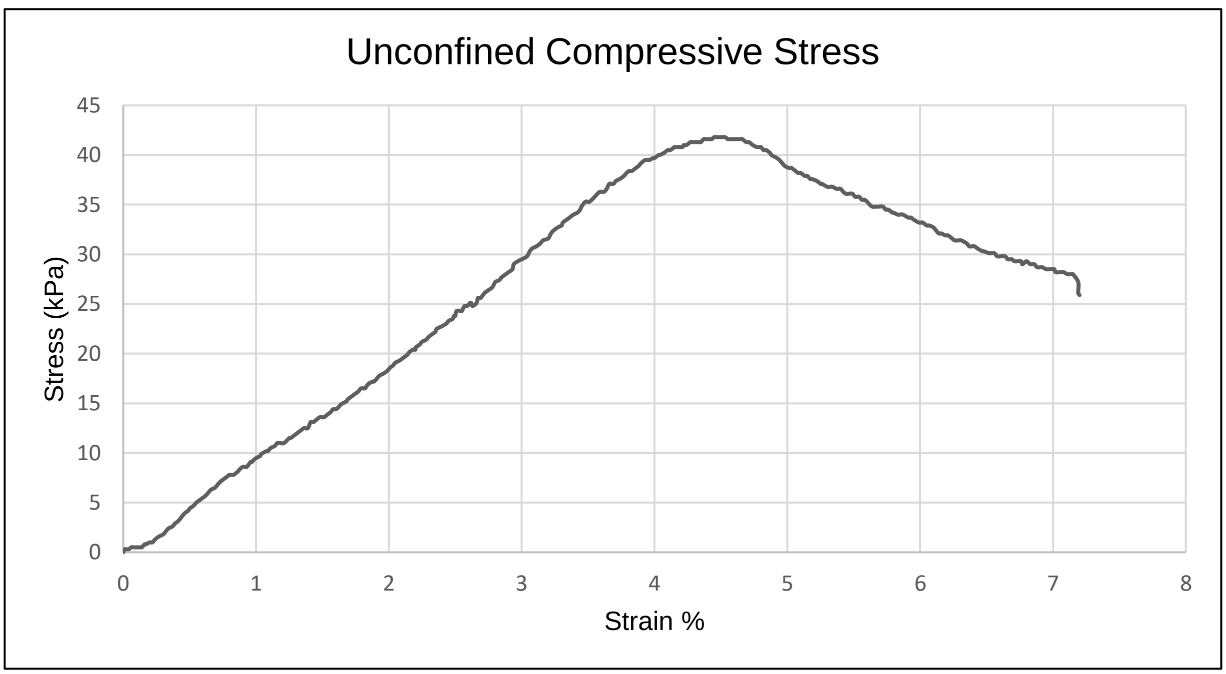
Core Dimensions

Initial Sample Diameter (mm)	69.80
Initial Sample Area (mm^2)	3826.49
Initial Sample Height (mm)	139.26
Initial Sample Volume (mm^3)	532877.2



Moisture Content

Tare Number	ST6
Tare + Wet Soil (g)	54.57
Tare + Dry Soil (g)	41.91
Mass of Water (g)	12.66
Mass of Tare (g)	21.23
Mass of Dry Soil (g)	20.68
Water Content (%)	61.22



Peak Load (kN)	0.16
At Displacement (mm)	6.31
Fail Stress (kPa)	41.81
Fail Strain %	4.53
Max Displacement (mm)	10.02
Strain Rate %/min	1.40
Max Strain %	7.20

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APPENDIX C

Chemical Analysis of Soil Samples
Samples Relating to Corrosion
(Paracel Laboratories Ltd. Order No. 2229240)

Report to: DS Studio
Project: 101873.001 (October 6, 2022)

Certificate of Analysis

Client: GEMTEC Consulting Engineers and Scientists Limited

Client PO:

Report Date: 21-Jul-2022

Order Date: 11-Jul-2022

Project Description: 101873.001

	Client ID:	BH22-01 SA3	-	-	-
	Sample Date:	11-Jul-22 13:23	-	-	-
	Sample ID:	2229240-01	-	-	-
	MDL/Units	Soil	-	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	72.2	-	-	-
General Inorganics					
Conductivity	5 uS/cm	419	-	-	-
pH	0.05 pH Units	7.44	-	-	-
Resistivity	0.10 Ohm.m	23.9	-	-	-
Anions					
Chloride	5 ug/g dry	42	-	-	-
Sulphate	5 ug/g dry	246	-	-	-

experience • knowledge • integrity

civil	civil
geotechnical	géotechnique
environmental	environnementale
field services	surveillance de chantier
materials testing	service de laboratoire des matériaux

expérience • connaissance • intégrité