August 27, 2013
File: PG3031-LET.01

Surface Developments Limited
61 Forest Hill Avenue,
Ottawa, Ontario
K2C 1P7

Attention: Mr. Jakub Ulak

Subject: Geotechnical Investigation
Proposed Residential Development
22 Perkins Street - Ottawa

Dear Sir,

Paterson Group (Paterson) was commissioned by Surface Developments Limited to conduct a geotechnical investigation for a proposed residential building to be located at the aforementioned site.

It is understood that the project consists of a three (3) storey apartment building with one (1) partial level of underground parking. It is also anticipated that an access lane and landscaping areas are also planned for the proposed development. The following letter report presents our findings and recommendations from a geotechnical perspective.

1.0 Field Observations

Surface Conditions

The subject site is currently occupied by a one (1) storey residential dwelling located within the west portion of the subject site. The east portion of the site is sparsely treed and grass covered. The east and south limits of the subject site are bordered by a vertical bedrock face. The site is bordered to the north by existing residential dwellings and to the west by Perkins Street. The site is approximately at grade with the neighbouring property to the north and with the adjacent roadway to the west.
Field Program

The field program for the geotechnical investigation was carried out on August 2, 2013. At that time, a total of six (6) test pits (TP 1 to TP 6) were excavated using a mini-excavator operated by a local contractor. All fieldwork was conducted under the full-time supervision of Paterson personnel under the direction of a senior engineer from the geotechnical division. The testing procedure consisted of excavating to the depths of refusal at the selected locations and regularly sampling the overburden. The approximate locations of the test holes are shown on Drawing PG3031-1 - Test Hole Location Plan attached to this report.

Subsurface Conditions

Generally, the subsoil conditions at the test hole locations consist of topsoil overlying existing unspecified fill consisting of varying amounts of topsoil, silty clay, sand, gravel, cobbles, trace boulders, brick, concrete, glass and plastic, in turn overlying the bedrock surface at depths ranging between 0.5 to 1.6 m below existing ground surface.

Based on available geological mapping, the subject site is located in an area where the bedrock consists primarily of interbedded fine crystalline limestone and calcareous shale of the Lindsay Formation. The overburden drift thickness is indicated to range from 0 to 2 m, which agrees with our observations.

Groundwater

Groundwater infiltration levels were measured in the open test holes upon completion of the sampling program. All test holes were noted to be dry upon completion of the field investigation. The groundwater table can also be estimated based on moisture levels and colour of the recovered soil samples. Based on these observations at the test hole locations, the permanent groundwater table is expected to be located at greater than 2 m in depth. It should be noted that groundwater levels are subject to seasonal fluctuations. Therefore, the groundwater level could vary at the time of construction.

Subsurface conditions observed at the test hole locations were recorded in detail in the field. Reference should be made to the Soil Profile and Test Data sheets, attached to this report, for specific details of the soil profile encountered at the test hole locations.
2.0 Geotechnical Assessment

From a geotechnical perspective, the subject site is suitable for the proposed residential development. Removal of bedrock will be required to accommodate the building, and the building will be founded on the bedrock.

Site Preparation and Fill Placement

Fill used for grading beneath the proposed building footprint, unless otherwise specified, should consist of clean imported granular fill, such as Ontario Provincial Standard Specifications (OPSS) Granular A or Granular B Type II. The fill should be tested and approved prior to delivery to the site. It should be placed in lifts no greater than 300 mm thick and compacted using suitable compaction equipment for the lift thickness. Fill placed beneath the proposed structure should be compacted to at least 98% of its standard Proctor maximum dry density (SPMDD).

Non-specified existing fill along with site-excavated soil can be used as general landscaping fill where settlement of the ground surface is of minor concern. These materials should be spread in thin lifts and at least compacted by the tracks of the spreading equipment to minimize voids. If these materials are to be used to build up the subgrade level for areas to be paved, they should be compacted in thin lifts to a minimum density of 95% of their respective SPMDD. Non-specified existing fill and site-excavated soils are not suitable for use as backfill against foundation walls.

Bedrock Removal

Bedrock removal can be accomplished by hoe ramming where only a small quantity of the bedrock needs to be removed. Sound bedrock may be removed by line drilling and controlled blasting and/or hoe ramming.

Prior to considering blasting operations, the blasting effects on the existing services, buildings and other structures should be addressed. A pre-blast or pre-construction survey of the existing structures located in proximity of the blasting operations should be carried out prior to commencing site activities. The extent of the survey should be determined by the blasting consultant and should be sufficient to respond to any inquiries/claims related to the blasting operations.

As a general guideline, peak particle velocities (measured at the structures) should not exceed 25 mm per second during the blasting program to reduce the risks of damage to the existing structures.
The blasting operations should be planned and conducted under the supervision of a licensed professional engineer who is also an experienced blasting consultant.

**Foundation Design**

Based on the subsurface profile encountered, it is expected that bedrock that meets the requirements of surface sounded bedrock will be encountered at the founding level.

Footings placed on surface sounded bedrock at the proposed founding elevation can be designed using a factored bearing resistance at ultimate limit states (ULS) value of **1,500 kPa**, incorporating a geotechnical resistance factor of 0.5, and a bearing resistance at serviceability limit states (SLS) value of **1,000 kPa**.

A clean, surface-sounded bedrock bearing surface should be free of all fill, soil and loose rock, whether in situ or not, and have no near surface seams, voids, fissures or open joints which can be detected from surface sounding with a rock hammer.

Footings placed on a suitably prepared bedrock bearing medium will experience negligible settlements.

**Design for Earthquakes**

The site class for seismic site response can be taken as **Site Class C** for the foundations considered at this site. A higher site class, such as Class B or A, may be appropriate for the subject site. However, site specific shear wave refraction/reflection testing would need to be conducted for confirmation of Site Class B or A. More information on site specific testing can be provided, if requested. The bearing media underlying the proposed shallow foundations are not susceptible to seismic liquefaction. Reference should be made to the latest revision of the 2006 Ontario Building Code for a full discussion of the earthquake design requirements.

**Basement Slab / Slab-on-Grade Construction**

With the removal of all topsoil and fill, containing deleterious material, within the footprint of the proposed buildings, the bedrock surface will be considered to be an acceptable subgrade on which to commence backfilling for floor slab construction.

OPSS Granular B Type II, with a maximum particle size of 50 mm, is recommended for backfilling below the floor slab. It is recommended that the upper 200 mm of sub-slab fill consist of OPSS Granular A crushed stone material. All backfill materials within the footprint of the proposed building should be placed in maximum 300 mm thick loose layers. The fill should be compacted to at least 98% of its SPMDD.
Pavement Structure

Car only parking and access lanes are anticipated at this site. The recommended pavement structures are presented in Tables 1 and 2.

**Table 1 - Recommended Pavement Structure - Car Only Parking**

<table>
<thead>
<tr>
<th>Thickness (mm)</th>
<th>Material Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>WEAR COURSE - HL-3 or SP 12.5 Asphaltic Concrete</td>
</tr>
<tr>
<td>150</td>
<td>BASE - OPSS Granular A Crushed Stone</td>
</tr>
<tr>
<td>300</td>
<td>SUBBASE - OPSS Granular B Type II</td>
</tr>
<tr>
<td></td>
<td>SUBGRADE - Either fill, bedrock, or OPSS Granular B Type I or II material placed over bedrock or fill</td>
</tr>
</tbody>
</table>

**Table 2 - Recommended Pavement Structure - Access Lanes**

<table>
<thead>
<tr>
<th>Thickness (mm)</th>
<th>Material Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>Wear Course - HL-3 or SP 12.5 Asphaltic Concrete</td>
</tr>
<tr>
<td>50</td>
<td>Binder Course - HL-8 or SP 19.0 Asphaltic Concrete</td>
</tr>
<tr>
<td>150</td>
<td>BASE - OPSS Granular A Crushed Stone</td>
</tr>
<tr>
<td>400</td>
<td>SUBBASE - OPSS Granular B Type II</td>
</tr>
<tr>
<td></td>
<td>SUBGRADE - Either fill, bedrock, or OPSS Granular B Type I or II material placed over bedrock or fill</td>
</tr>
</tbody>
</table>

Minimum Performance Graded (PG) 58-34 asphalt cement should be used for this project. If soft spots develop in the subgrade during compaction or due to construction traffic, the affected areas should be excavated and replaced with OPSS Granular B Type I or II material.

The pavement granular base and subbase should be placed in maximum 300 mm thick lifts and compacted to a minimum of 98% of the material’s SPMDD using suitable compaction equipment.

**Pavement Structure Drainage**

The long-term performance of the pavement structure is improved by keeping the contact zone between the subgrade material and the granular subbase in a drained condition. This can be effected by sloping the subgrade toward drainage structures and providing subsurface inlets or stubby subdrains into catch basins, where practical.
3.0 Design and Construction Precautions

Foundation Drainage and Backfill

It is recommended that a perimeter foundation drainage system be provided for the proposed structure. The system should consist of a 100 to 150 mm diameter, geotextile-wrapped, perforated, corrugated, plastic pipe, surrounded on all sides by 150 mm of 19 mm clear crushed stone, placed at the footing level around the exterior perimeter of the structure. The pipe should have a positive outlet, such as a gravity connection to the storm sewer.

Backfill against the exterior sides of the foundation walls should consist of free-draining, non frost susceptible granular materials. The site materials will be frost susceptible and, as such, are not recommended for re-use as backfill unless a composite drainage system (such as system Platon or Miradrain G100N) connected to a drainage pipe is provided.

Protection of Footings Against Frost Action

Perimeter footings of heated structures are required to be insulated against the deleterious effect of frost action. A minimum of 1.5 m of soil cover alone, or a minimum of 0.6 m of soil cover, in conjunction with foundation insulation, should be provided in this regard. Note that if the bearing medium is determined to be non frost susceptible, the soil cover requirements are not applicable (see following section).

Exterior unheated footings, such as those for isolated exterior piers, are more prone to deleterious movement associated with frost action than the exterior walls of the structure proper and require additional protection, such as soil cover of 2.1 m or a combination of soil cover and subfooting foundation insulation.

Frost Susceptibility of Bedrock

When bedrock is encountered above the proposed founding depth and soil frost cover is less than the 1.5 m, the frost susceptibility of the bedrock can be determined as an alternative to providing foundation insulation. This can be accomplished as follows:

- Drill probe holes within the bedrock and assess its frost susceptibility.
- Examine service trench profiles extending in bedrock in the vicinity of the foundation to determine if weathering is extensive.

If the bedrock is considered to be non-frost susceptible, the footings can be placed directly on the bedrock without any further frost protective measures.
If the bedrock is considered to be frost susceptible, the following measures should be implemented for frost protection:

- **Option A** - Subexcavate the weathered bedrock to sound or intact bedrock or to the required frost cover depth. Pour footings at the lower level.

- **Option B** - Use insulation to protect footings. For footings adjacent to a heated space the insulation can be located down the exterior face of the foundation wall and horizontally out over and beyond the top of the footings. For footings of unheated structures a subfooting insulation configuration is required. Further details for foundation insulation can be provided as required.

**Excavation Side Slopes**

The side slopes of excavations in the soil and fill overburden materials should either be cut back at acceptable slopes or should be retained by shoring systems from the start of the excavation until the structure is backfilled. It is assumed that sufficient room will be available for the greater part of the excavation to be undertaken by open-cut methods (i.e. unsupported excavations).

The excavation side slopes above the groundwater level extending to the full expected thickness of the overburden should be cut back at 1H:1V or flatter. A flatter slope is required for excavation below groundwater level, if a perched groundwater condition is experienced over the bedrock surface during construction. The subsoil at this site is considered to be mainly Type 2 soil according to the Occupational Health and Safety Act and Regulations for Construction Projects.

Excavation side slopes in sound bedrock can be carried out using almost vertical side walls. A minimum 1 m horizontal ledge, should be left between the bottom of the overburden excavation and the top of the bedrock surface to provide an area to allow for potential sloughing of the overburden.

Excavated soil should not be stockpiled directly at the top of excavations and heavy equipment should be kept away from the excavation sides.

It is recommended that a trench box be used at all times to protect personnel working in trenches with steep or vertical sides. It is expected that services will be installed by “cut and cover” methods and excavations will not be left open for extended periods of time.
Groundwater Control

The contractor should be prepared to direct water away from all bearing surfaces and subgrades, regardless of the source, to prevent disturbance to the founding medium.

It is anticipated that pumping from open sumps will be sufficient to control the groundwater influx through the sides of the excavations.

4.0 Field Review and Materials Testing Program

It is a requirement for the design data provided herein to be applicable that an acceptable filed review and materials testing program, including the aspects shown below, be performed by the geotechnical consultant.

- Observation of all bearing surfaces prior to the placement of concrete.
- Sampling and testing of the concrete and fill materials used.
- Observation of all subgrades prior to backfilling and follow-up field density tests to determine the level of compaction achieved.
- Sampling and testing of the bituminous concrete including mix design reviews.

Upon demand, a report confirming that these works have been conducted in general accordance with our recommendations could be issued following the completion of a satisfactory materials testing and observation program by the geotechnical consultant.
5.0 Statement of Limitations

The recommendations made in this report are in accordance with our present understanding of the project. We request that we be permitted to review the grading plan once available. Also, our recommendations should be reviewed when the project drawings and specifications are complete.

A soils investigation is a limited sampling of a site. Should any conditions at the site be encountered which differ from those at the test locations, we request that we be notified immediately in order to permit reassessment of our recommendations.

The present report applies only to the project described in this document. Use of this report for purposes other than those described herein or by person(s) other than Surface Developments or their agent(s) are not authorized without review by this firm for the applicability of our recommendations to the altered use of the report.

Paterson Group Inc.

Richard Groniger, C.Tech.

Andrew J. Tovell, P.Eng.

Attachments

- Soil Profile and Test Data Sheets
- Symbols and Terms
- Figure 1 - Key Plan
- Drawing PG3031-1 - Test Hole Location Plan

Report Distribution

- Surface Developments Ltd. (3 hard copies and an electronic copy)
- Paterson Group (1 copy)
**SOIL PROFILE AND TEST DATA**

**Geotechnical Investigation**  
Prop. Residential Development - 22 Perkins Street  
Ottawa, Ontario

**DATE**  
August 2, 2013

**BORINGS BY**  
Hydraulic Shovel

---

**SOIL DESCRIPTION**

<table>
<thead>
<tr>
<th>STRATA PLOT</th>
<th>SAMPLE</th>
<th>DEPTH (m)</th>
<th>ELEV. (m)</th>
<th>Pen. Resist. Blows/0.3m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0 - 64.87</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**GROUND SURFACE**

- **FILL:** Topsoil with organics, sand, gravel, trace brick and concrete

- **FILL:** Brown silty clay with sand, gravel, some boulders

  End of Test Pit

  Test pit terminated on bedrock surface at 0.80m depth

  (TP dry upon completion)

---

**Remoulded**  

![Piezometer](image)

**Datums:**  
TBM - Top spindle of fire hydrant located in front of 19 Perkins Street. Geodetic elevation = 63.99m, as per Stantec Geomatics Limited.

**Remarks:**  
Hydraulic Shovel

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**File No.:** PG3031  
**Hole No.:** TP 1

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**Prop. Residential Development - 22 Perkins Street, 154 Colonnade Road South, Ottawa, Ontario K2E 7J5**  
Geotechnical Investigation  
August 2, 2013  
Hydraulic Shovel  
TBM - Top spindle of fire hydrant located in front of 19 Perkins Street. Geodetic elevation = 63.99m, as per Stantec Geomatics Limited.
**SOIL PROFILE AND TEST DATA**

**Geotechnical Investigation**
Prop. Residential Development - 22 Perkins Street
Ottawa, Ontario

**DATE** August 2, 2013

**FILE NO.** PG3031

**HOLE NO.** TP 2

**DATUM**
TBM - Top spindle of fire hydrant located in front of 19 Perkins Street. Geodetic elevation = 63.99m, as per Stantec Geomatics Limited.

**BORINGS BY** Hydraulic Shovel

**REMINDERS**

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<table>
<thead>
<tr>
<th>SOIL DESCRIPTION</th>
<th>STRATA PLOT</th>
<th>SAMPLE</th>
<th>DEPTH (m)</th>
<th>ELEV. (m)</th>
<th>Pen. Resist. Blows/0.3m</th>
<th>Shear Strength (kPa)</th>
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<td><strong>GROUND SURFACE</strong></td>
<td><img src="image" alt="STRATA PLOT" /></td>
<td><img src="image" alt="SAMPLE" /></td>
<td>0 - 67.51</td>
<td>0 - 67.51</td>
<td><img src="image" alt="Water Content %" /></td>
<td><img src="image" alt="Undisturbed Remoulded" /></td>
</tr>
<tr>
<td><strong>FILL:</strong> Topsoil with organics, sand, some crushed stone and cobbles, trace boulders and brick</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>G 1</td>
<td>2</td>
<td>66.51</td>
<td>50 mm Dia. Cone</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>G 2</td>
<td>2</td>
<td>66.51</td>
<td>50 mm Dia. Cone</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>End of Test Pit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Test pit terminated on bedrock surface at 1.10m depth</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(TP dry upon completion)</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

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**REMARKS**

Prop. Residential Development - 22 Perkins Street
154 Colonnade Road South, Ottawa, Ontario K2E 7J5

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**TBM - Top spindle of fire hydrant located in front of 19 Perkins Street. Geodetic elevation = 63.99m, as per Stantec Geomatics Limited.**
**SOIL DESCRIPTION**

**GROUND SURFACE**

**FILL:** Topsoil with clay, gravel, cobbles, trace boulders, plaster, brick and styrofoam

End of Test Pit

Test pit terminated on bedrock surface at 0.45m depth

(TP dry upon completion)
**SOIL PROFILE AND TEST DATA**

**Geotechnical Investigation**

**Prop. Residential Development - 22 Perkins Street**

Ottawa, Ontario

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**DATUM**

TBM - Top spindle of fire hydrant located in front of 19 Perkins Street. Geodetic elevation = 63.99m, as per Stantec Geomatics Limited.

**REMARKS**

Borings by Hydraulic Shovel

**DATE**

August 2, 2013

**FILE NO.**

PG3031

**HOLE NO.**

TP 4

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<table>
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<th>BORINGS BY</th>
<th>Hydraulic Shovel</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATE</td>
<td>August 2, 2013</td>
</tr>
</tbody>
</table>

---

**SOIL DESCRIPTION**

**GROUND SURFACE**

**FILL:** Topsoil with gravel, cobbles, trace brick, plastic and glass

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**SAMPLE**

<table>
<thead>
<tr>
<th>STRATA PLOT</th>
<th>SAMPLE</th>
<th>DEPTH (m)</th>
<th>ELEV. (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0 - 65.10</td>
<td>65.10</td>
</tr>
</tbody>
</table>

---

**FILL:** Brown silty clay with topsoil, gravel, cobbles, trace brick, plastic and glass

---

**End of Test Pit**

Test pit terminated on bedrock surface at 1.05m depth

(TP dry upon completion)
# Soil Profile and Test Data

**Prop. Residential Development - 22 Perkins Street**

**Ottawa, Ontario**

**August 2, 2013**

**File No.: PG3031**

**Hole No.: TP 5**

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## Soil Description

<table>
<thead>
<tr>
<th>Strata Plot</th>
<th>Sample</th>
<th>Depth (m)</th>
<th>Elev. (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ground Surface</strong></td>
<td></td>
<td>0 - 65.49</td>
<td></td>
</tr>
</tbody>
</table>

**Fill:** Grey sand with gravel, cobbles, shale, trace brick, glass and slag

<table>
<thead>
<tr>
<th>Strata Plot</th>
<th>Sample</th>
<th>Depth (m)</th>
<th>Elev. (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.10</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Fill:** Brown silty sand with clay, gravel, cobbles and boulders

<table>
<thead>
<tr>
<th>Strata Plot</th>
<th>Sample</th>
<th>Depth (m)</th>
<th>Elev. (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.55</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**End of Test Pit**

Test pit terminated on bedrock surface at 1.55m depth

(TP dry upon completion)

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## Pen. Resist. Blows/0.3m

- **50 mm Dia. Cone**
- **Water Content %**

---

### Shear Strength (kPa)

- Undisturbed
- Remoulded
**SOIL DESCRIPTION**

<table>
<thead>
<tr>
<th>STRATA PLOT</th>
<th>SAMPLE</th>
<th>DEPTH (m)</th>
<th>ELEV. (m)</th>
<th>Pen. Resist. Blows/0.3m</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0 - 65.18</td>
<td></td>
<td>50 mm Dia. Cone</td>
</tr>
</tbody>
</table>

**FILL:** Topsoil with brick, gravel, cobbles, trace organics

End of Test Pit

Test pit terminated on bedrock surface at 0.53m depth

(TP dry upon completion)

---

**BORINGS BY** Hydraulic Shovel

**DATE** August 2, 2013

**FILE NO.** PG3031

**HOLE NO.** TP 6

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**ELEVATION**

Date: August 2, 2013

Daturn: TBM - Top spindle of fire hydrant located in front of 19 Perkins Street. Geodetic elevation = 63.99m, as per Stantec Geomatics Limited.

**REMARKS**

1. Water Content %
2. Pen. Resist. Blows/0.3m
3. 50 mm Dia. Cone

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**SOIL PROFILE AND TEST DATA**

Geotechnical Investigation
Prop. Residential Development - 22 Perkins Street
Ottawa, Ontario

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**SOIL DESCRIPTION**

- **GROUND SURFACE**
  - FILL: Topsoil with brick, gravel, cobbles, trace organics
  - End of Test Pit
  - Test pit terminated on bedrock surface at 0.53m depth
  - (TP dry upon completion)
**SYMBOLS AND TERMS**

**SOIL DESCRIPTION**

Behavioural properties, such as structure and strength, take precedence over particle gradation in describing soils. Terminology describing soil structure are as follows:

- **Desiccated** - having visible signs of weathering by oxidation of clay minerals, shrinkage cracks, etc.
- **Fissured** - having cracks, and hence a blocky structure.
- **Varved** - composed of regular alternating layers of silt and clay.
- **Stratified** - composed of alternating layers of different soil types, e.g. silt and sand or silt and clay.
- **Well-Graded** - Having wide range in grain sizes and substantial amounts of all intermediate particle sizes (see Grain Size Distribution).
- **Uniformly-Graded** - Predominantly of one grain size (see Grain Size Distribution).

The standard terminology to describe the strength of cohesionless soils is the relative density, usually inferred from the results of the Standard Penetration Test (SPT) ‘N’ value. The SPT N value is the number of blows of a 63.5 kg hammer, falling 760 mm, required to drive a 51 mm O.D. split spoon sampler 300 mm into the soil after an initial penetration of 150 mm.

<table>
<thead>
<tr>
<th>Relative Density</th>
<th>‘N’ Value</th>
<th>Relative Density %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Loose</td>
<td>&lt;4</td>
<td>&lt;15</td>
</tr>
<tr>
<td>Loose</td>
<td>4-10</td>
<td>15-35</td>
</tr>
<tr>
<td>Compact</td>
<td>10-30</td>
<td>35-65</td>
</tr>
<tr>
<td>Dense</td>
<td>30-50</td>
<td>65-85</td>
</tr>
<tr>
<td>Very Dense</td>
<td>&gt;50</td>
<td>&gt;85</td>
</tr>
</tbody>
</table>

The standard terminology to describe the strength of cohesive soils is the consistency, which is based on the undisturbed undrained shear strength as measured by the in situ or laboratory vane tests, penetrometer tests, unconfined compression tests, or occasionally by Standard Penetration Tests.

<table>
<thead>
<tr>
<th>Consistency</th>
<th>Undrained Shear Strength (kPa)</th>
<th>‘N’ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Soft</td>
<td>&lt;12</td>
<td>&lt;2</td>
</tr>
<tr>
<td>Soft</td>
<td>12-25</td>
<td>2-4</td>
</tr>
<tr>
<td>Firm</td>
<td>25-50</td>
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<tr>
<td>Stiff</td>
<td>50-100</td>
<td>8-15</td>
</tr>
<tr>
<td>Very Stiff</td>
<td>100-200</td>
<td>15-30</td>
</tr>
<tr>
<td>Hard</td>
<td>&gt;200</td>
<td>&gt;30</td>
</tr>
</tbody>
</table>
SOIL DESCRIPTION (continued)

Cohesive soils can also be classified according to their “sensitivity”. The sensitivity is the ratio between the undisturbed undrained shear strength and the remoulded undrained shear strength of the soil.

Terminology used for describing soil strata based upon texture, or the proportion of individual particle sizes present is provided on the Textural Soil Classification Chart at the end of this information package.

ROCK DESCRIPTION

The structural description of the bedrock mass is based on the Rock Quality Designation (RQD).

The RQD classification is based on a modified core recovery percentage in which all pieces of sound core over 100 mm long are counted as recovery. The smaller pieces are considered to be a result of closely-spaced discontinuities (resulting from shearing, jointing, faulting, or weathering) in the rock mass and are not counted. RQD is ideally determined from NXL size core. However, it can be used on smaller core sizes, such as BX, if the bulk of the fractures caused by drilling stresses (called “mechanical breaks”) are easily distinguishable from the normal in situ fractures.

<table>
<thead>
<tr>
<th>RQD %</th>
<th>ROCK QUALITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>90-100</td>
<td>Excellent, intact, very sound</td>
</tr>
<tr>
<td>75-90</td>
<td>Good, massive, moderately jointed or sound</td>
</tr>
<tr>
<td>50-75</td>
<td>Fair, blocky and seamy, fractured</td>
</tr>
<tr>
<td>25-50</td>
<td>Poor, shattered and very seamy or blocky, severely fractured</td>
</tr>
<tr>
<td>0-25</td>
<td>Very poor, crushed, very severely fractured</td>
</tr>
</tbody>
</table>

SAMPLE TYPES

<table>
<thead>
<tr>
<th>SS</th>
<th>Split spoon sample (obtained in conjunction with the performing of the Standard Penetration Test (SPT))</th>
</tr>
</thead>
<tbody>
<tr>
<td>TW</td>
<td>Thin wall tube or Shelby tube</td>
</tr>
<tr>
<td>PS</td>
<td>piston sample</td>
</tr>
<tr>
<td>AU</td>
<td>Auger sample or bulk sample</td>
</tr>
<tr>
<td>WS</td>
<td>Wash sample</td>
</tr>
<tr>
<td>RC</td>
<td>Rock core sample (Core bit size AXT, BXL, etc.). Rock core samples are obtained with the use of standard diamond drilling bits.</td>
</tr>
</tbody>
</table>
SYMBOLS AND TERMS (continued)

GRAIN SIZE DISTRIBUTION

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC%</td>
<td>Natural moisture content or water content of sample, %</td>
</tr>
<tr>
<td>LL</td>
<td>Liquid Limit, % (water content above which soil behaves as a liquid)</td>
</tr>
<tr>
<td>PL</td>
<td>Plastic limit, % (water content above which soil behaves plastically)</td>
</tr>
<tr>
<td>PI</td>
<td>Plasticity index, % (difference between LL and PL)</td>
</tr>
<tr>
<td>Dxx</td>
<td>Grain size which xx% of the soil, by weight, is of finer grain sizes</td>
</tr>
<tr>
<td>D10</td>
<td>Grain size at which 10% of the soil is finer (effective grain size)</td>
</tr>
<tr>
<td>D60</td>
<td>Grain size at which 60% of the soil is finer</td>
</tr>
</tbody>
</table>

These grain size descriptions are not used below 0.075 mm grain size.

Cc = Concavity coefficient = \((D30)^2 / (D10 \times D60)\)

Cu = Uniformity coefficient = \(D60 / D10\)

Cc and Cu are used to assess the grading of sands and gravels:
Well-graded gravels have: \(1 < Cc < 3 \) and \( Cu > 4 \)
Well-graded sands have: \(1 < Cc < 3 \) and \( Cu > 6 \)
Sands and gravels not meeting the above requirements are poorly-graded or uniformly-graded.
Cc and Cu are not applicable for the description of soils with more than 10% silt and clay (more than 10% finer than 0.075 mm or the #200 sieve).

CONSOLIDATION TEST

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(p'_o)</td>
<td>Present effective overburden pressure at sample depth</td>
</tr>
<tr>
<td>(p'_c)</td>
<td>Preconsolidation pressure of (maximum past pressure on) sample</td>
</tr>
<tr>
<td>Ccr</td>
<td>Recompression index (in effect at pressures below (p'_c))</td>
</tr>
<tr>
<td>Cc</td>
<td>Compression index (in effect at pressures above (p'_c))</td>
</tr>
</tbody>
</table>

OC Ratio = Overconsolidation ratio = \(p'_c / p'_o\)
Void Ratio = Initial sample void ratio = volume of voids / volume of solids
Wo = Initial water content (at start of consolidation test)

PERMEABILITY TEST

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>k</td>
<td>Coefficient of permeability or hydraulic conductivity is a measure of the ability of water to flow through the sample. The value of k is measured at a specified unit weight for (remoulded) cohesionless soil samples, because its value will vary with the unit weight or density of the sample during the test.</td>
</tr>
</tbody>
</table>
FIGURE 1
KEY PLAN