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May 4, 2018 File: 62672.03

Pinecrest Remembrance Services
2500 Baseline Road
Ottawa, Ontario
K2C 3H9

Attention: Mr. John Cole

**Re: Geotechnical Design Parameters**
**Proposed Retaining Walls**
**Highland Park Remembrance**
**2037 McGee Side Road**

## INTRODUCTION

This letter provides geotechnical parameters for the design of the proposed retaining walls associated with the above noted project. It is understood that the geometry of the walls has not be finalized; however, based on the information provided to us, the general arrangement of the walls is summarized below:

- The proposed grade along the base of the wall will be located slightly above elevation 110.0 metres;
- The proposed grade behind the wall could be located between elevation 111.2 and 111.9 metres; and
- The proposed grade behind the wall will be sloping at between 15 to 20 degrees.

It is further understood that a concrete slab on grade for a chiller unit may be located behind the retaining wall.

## OVERVIEW OF SUBSURFACE CONDITIONS

A summary of the subsurface conditions encountered in the test holes previously advanced in the area of the proposed retaining walls (i.e., boreholes 101 and 102, and test pits 105 to 107) is provided below:

- In general, the overburden is composed stiff to very stiff, grey brown silty clay followed by glacial till at about elevation 107.5 to 108.3. The glacial till is reported to have a very loose to dense relative density. A layer of sandy silt was encountered within the silty clay.

- The inferred bedrock surface was encountered at between elevation 106.8 and 107.6 metres.
- The groundwater level was at elevation 109.7 metres on February 19, 2010.

## RECOMMENDATIONS AND GUIDELINES

### Excavation

The excavation for the proposed retaining walls will be carried out through silty clay, sandy silt, and possibly glacial till. The sides of the excavation should be sloped in accordance with the requirements in Ontario Regulation 213/91 under the Occupational Health and Safety Act. According to the act, soils at this site can be classified as Type 3. That is, open cut excavations within overburden deposits should be carried out with side slopes of 1 horizontal to 1 vertical, or flatter.

It is anticipated that groundwater inflow from the overburden deposits into the excavations could be handled from within the excavations. It is not expected that short term pumping during excavation will have a significant effect on nearby structures and utilities.

### Potential for Subgrade Disturbance

Depending on the depth of the excavation, saturated deposits of silty clay, sandy silt, and glacial till may be encountered at subgrade level. When saturated, these deposits are susceptible to weakening under vibration and/or repeated loading. For excavation below about elevation 109.7 metres, we recommend that a contingency allowance be made for a 300 millimetre thick subbedding layer of OPSS Granular B Type II granular material and a woven geotextile separator meeting OPSS 1860 Class I requirements in the event that the subgrade soils are disturbed during construction. Where saturated soil deposits are encountered, a 75 to 100 millimetre (minimum) thick layer of low strength concrete, placed immediately following excavation, is recommended to reduce the potential for subgrade disturbance.

From a geotechnical point of view, consideration could be given to raising the planned founding level to as high as practicable in order to reduce the potential for disturbance to the soils in the bottom of the excavation. For this case, thermal insulation may be required. A test excavation could be carried out in advance of construction to assess the effect of excavation related disturbance and confirm the optimal founding level for the walls.

### Spread Footing Design

The proposed walls could be founded on spread footings bearing on or within native, undisturbed soil. In areas where the underside of footing level is above the level of the subgrade or where subexcavation of soil is required, the grade below the proposed building could be raised with imported granular material conforming to OPSS Granular B Type II compacted in maximum 200 millimetre thick lifts to at least 95 percent of the standard Proctor dry density value. To provide adequate spread of load below the footings, the material should extend at least 0.5 metres horizontally beyond the edge of the footings and down and out from this point at 1 horizontal to 1 vertical, or flatter.

Spread footings founded on or within native undisturbed soil, or on a pad of compacted granular fill above native undisturbed soil, should be sized using a net geotechnical reaction at Serviceability Limit State (SLS) of 100 kilopascals and a factored net geotechnical resistance at Ultimate Limit State (ULS) of 250 kilopascals.

The post construction total and differential settlement at SLS should be less than 25 and 20 millimetres, respectively, provided that all loose or disturbed soil is removed from the bearing surfaces.

**Sliding Resistance of Footings**

For design purposes, the resistance to sliding of the retaining walls could be calculated using an unfactored interface friction angle of 22 degrees, assuming that the footings are founded directly on native soil. If the footings are founded on a pad of compacted granular material, unfactored interface friction angle could be increased to 29 degrees.

**Frost Protection of the Foundations**

Footings located in unheated areas that are to be cleared of snow should be provided with at least 1.8 metres of earth cover for frost protection purposes. As previously indicated, we recommend that the foundations be raised to as high as practicable in order to reduce the potential for disturbance to the soils in the bottom of the excavation. For this case, 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. It is noted that in order to achieve the bearing values provided above, any insulation used below the footings should consist of DOW HI 40 or approved equivalent.

**Backfill and Drainage**

The retaining walls should be backfilled with imported, free draining, non-frost susceptible granular material such as that meeting OPSS Granular B Type I or II requirements.

Where the backfill will ultimately support areas of hard surfacing (i.e., chiller unit slab, pavement, sidewalks or other similar surfaces), the backfill should be placed in maximum 200 millimetre thick lifts and should be compacted to at least 98 percent of the standard Proctor maximum dry density value using suitable compaction equipment. 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 for the hard surfaced areas. The frost tapers should be sloped at 1 horizontal to 1 vertical, or flatter.

Where future landscaped areas will exist next to the proposed structure and if some settlement of the backfill is acceptable, the backfill could be compacted to at least 90 percent of the standard Proctor maximum dry density value.

As a minimum, a perforated drain with a surround of clear crushed stone should be installed along the base of the retaining walls, below finished grade. The drains should outlet by gravity to a storm sewer or a sump from which the water is pumped. To avoid loss of sand backfill into the voids in the clear stone (and possible post construction settlement of the ground around the building/wall), a nonwoven geotextile should be placed between the clear stone and any sand backfill material.

**Earth Pressure Parameters**

The static at rest thrust ($P_o$) acting on the wall should be calculated using the following formula:

$$P_o = 0.5\ K_o\ \gamma\ H^2$$

where;

- $P_o$: Static at rest thrust component (kN/m);
- $\gamma$: Moist material unit weight (kN/m$^3$);
- $K_o$: "At Rest" earth pressure coefficient;
- H: Wall height (m).

Seismic shaking can increase the forces on the retaining wall. The total at rest thrust acting on the wall ($P_{oe}$) during a seismic event is composed of a static component ($P_o$) and a dynamic component ($P_e$), that is:

$$P_{oe} = P_o + P_e$$

The dynamic at rest thrust component ($P_e$), which acts only during seismic loading conditions, should be calculated using the following formula:

$$P_e = 0.5\ (K_{oe} - K_o)\ \gamma\ H^2$$

where;

- $P_e$: Dynamic at rest thrust component (kN/m);
- $\gamma$: Moist material unit weight (kN/m$^3$);
- $K_o$: "At Rest" earth pressure coefficient;

- $K_{oe}$: Dynamic at rest earth pressure coefficient;
- H: Wall height (m).

The static thrust component ($P_o$) acts at a point located H/3 above the base of the wall. During seismic shaking, the dynamic at rest thrust component ($P_e$) acts at a point located about 0.6H above the base of the wall.

For design purposes, the soil parameters provided in Table 1 can be used to calculate the at rest thrust components acting on the wall.

**Table 1 - Summary of Soil Parameters for At Rest Wall**

| Parameter | OPSS Granular B Type I | OPSS Granular B Type II |
|---|---|---|
| Material Unit Weight, $\gamma$ ($kN/m^3$) | 21 | 22 |
| Estimated Friction Angle (degrees) | 34 | 38 |
| "At Rest" Earth Pressure Coefficient, $K_o$, assuming retained soil sloping at 20 degrees | 0.59 | 0.51 |
| Dynamic At Rest Earth Pressure Coefficient, $K_{oe}$, assuming retained soil sloping at 20 degrees | 0.77[1] | 0.69[1] |

Notes:

1) According to the 2012 Ontario Building Code, the peak ground acceleration (PGA) for Ottawa is 0.32 for firm ground conditions (i.e., for Site Class C). For this particular site, the corrected PGA can be taken as 0.37 (Site Class D). The dynamic at rest earth pressure coefficient was calculated using the method suggested by Mononobe and Okabe, assuming a horizontal seismic coefficient, $k_h$, of 0.37 (taken as the corrected PGA) and assuming that the vertical seismic coefficient, $k_v$, is zero.

### Chiller Pad Impacts

The theory of elasticity can be used to determine the lateral earth pressure on unyielding retaining walls caused by strip loading. The lateral earth pressure acting on the wall depends on the geometry of the strip loading. For the following scenario: (a) the chiller pad has a width of about 2 metres; (b) the chiller pad is located about 0.5 metres from the back of the wall; and (c) the underside of the chiller pad is located about 0.85 metres above finished grade along the base of the wall, the total force acting on the wall due to the strip loading only ($P_{strip}$) should be calculated using the following formula, assuming that the concrete slab used to support the chiller unit acts as a uniformly loaded strip:

$P_{strip} = 0.38\ q$

where;

- $P_{strip}$: Horizontal thrust component associated with the strip loading (kN/m)
- q: Uniform surcharge acting within the footprint of the concrete slab (kN/m$^2$);

The thrust component associated with the strip loading ($P_{strip}$) acts at a point located 0.25 metres above the base of the wall.

By way of example, if the chiller pad supports a surcharge (q) of 50 kPa, the horizontal thrust component acting on the wall ($P_{strip}$) has a magnitude of 19 kN/m.

The magnitude and location of $P_{strip}$ are dependant on the location of the chiller pad. The magnitude and location of $P_{strip}$ for other chiller pad locations could be provided upon request.

**Global Stability**

Slope stability analyses were carried out in order to determine the existing factor of safety against global stability during static and seismic loading conditions. The global stability analyses were carried out using SLIDE, a state of the art, two-dimensional limit equilibrium slope stability program.

The soil conditions and strength parameters used in the stability analyses were based, in part, on the results of the test holes previously advanced at the site. The results of a stability analysis are highly dependent on the assumed groundwater conditions. As a conservative approach, we have assumed full hydrostatic saturation with the groundwater level at the surface of the native soil.

In an attempt to model seismic loading conditions, a pseudo-static slope stability analysis was carried out using a seismic coefficient ($k_h$) of 0.2.

The following geometry was analysed:

- A wall height of about 0.9 metres;
- A chiller pad, having a width of 2 metres, located about 0.5 metres behind the wall;
- The underside of the chiller pad located 0.9 metres above the base of the wall;
- A uniform surcharge of 50 kilopascals acts within the footprint of the chiller pad; and
- The retained soil, above and below the chiller pad, is inclined at 20 degrees to elevation 112 metres.

Based on the results of the analyses, the geometry described above has an adequate factor of safety against global instability for both static and seismic loading conditions.

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

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