# SUBSURFACE INVESTIGATION REPORT

## 265 CENTRUM BOULEVARD, OTTAWA, ON, K2S 1V4

**Abstract**

This report presents the findings of a Subsurface Investigation completed at the 265 Centrum Boulevard parcel, in the City of Ottawa, ON and issue recommendations for a proposed 3 high rise buildings development. It provides technical information about the subsurface conditions at 6 borehole locations compiled from field sampling and testing. Two of the boreholes were advanced through bedrock with one or more 1.52 m core barrel runs and the remainder boreholes were advanced to either of auger refusal and/or sampler refusals. Bedrock depths range between at surface outcrops along the south side of the property to 11 m depth at the north west and 30 m depth at the north east. The majority of the soil profile consists on stiff silty clay. The borehole locations are shown in figure 1 in page 9. The information reviewed also includes readily available geologic information from the Geological Survey of Canada (GSC) and local climate data from Environment Canada.

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[1] For the account of Bayview Orleans Inc. (BOI) as per proposal in email dated September 26, 2021 and subject to the user agreement in page 25 .

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# Contents

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# 1 Introduction

This document reports the findings of a subsurface investigation completed at 265 Centrum Boulevard, in the City of Ottawa, ON, K2S 1V4, having extents and geometry shown in figure 1 in page 9. The geotechnical materials in Ottawa and the surrounding areas are largely influenced by a history of glaciation, glacio-fluvial activity and the Champlain Sea. Common overburden materials include clay, very sensitive silty clay, till, boulder till, clean sand and silty sand overlying sedimentary rocks. Igneous and metamorphic rocks are also present. Organic materials have also influenced numerous soil deposits.

The investigation was carried out by advancing 6 boreholes through overburden soils and by proving bedrock depth by available exploration techniques for engineering purposes. The information compiled from the exploration and sampling and testing completed in the boreholes and a subsequent laboratory testing program of soils is to assist in the design and construction of a proposed 3 high rise buildings development. The information reviewed also includes readily available geologic information from the Geological Survey of Canada (GSC), and local climate data from Environment Canada.

# 2 Report Organization

The body of this report and its appendices constitute the entire report. The discussion presented under sections in the body may refer to further information and/or background and/or details in the appendices. The reader is responsible of reviewing the information in the appendices. Other references may be presented as footnotes.

Future revisions to this report will be referred to as “54-BOI-R2#”, where # is the consecutive number of the revision. Additions and/or alterations and/or inclusions to the information provided in this report at the request of any institution and/or body with authority to request the additions and/or alterations and/or inclusion will be provided in a separate “Response to ” (RT) section at the end of the report, before the appendices. The RT section shall state the section that is added and/or altered, the name of the person making the request and the reason. The section altered and or portions added will be provided in full as a subsection of the RT section. Any subsection added under the RT section will be considered a replacement to the original section.

# Part I
# Investigation

## 3 Sampling and Testing

The field and laboratory program set out in our proposal is guided by the following standards:

- ASTM D 420-98 Standard Guide to Site Characterization for Engineering Design and Construction Purposes,
- ASTM D5434 - 12 Standard Guide for Field Logging of Subsurface Explorations of Soil and Rock,
- ASTM D1586 - 11 Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils,
- ASTM D1586 - 11 based Dynamic Cone Penetration Test (DCPT),
- ASTM D2573 - 08 Standard Test Method for Field Vane Shear Test in Cohesive Soil.
- ASTM D2113 - 14 Standard Practice for Rock Core Drilling and Sampling of Rock for Site Exploration;

The ASTM D1586 tests were completed using an “auto safety” hammer rated at 60% energy.

The field program consisted in sampling the subsurface profile using boreholes located as shown in fig. 1 in page 9 along with field review, assessments and classification of samples.

The program also included an elevation survey referenced to the top spindle of the fire hydrant located on the north side of Brisebois Crescent which is understood to have a 66.59 m geodetic elevation. The program included in addition a laboratory review of samples recovered from the field.

The laboratory testing, soil sampling and field testing at each location are shown in the soil profile testing and sampling logs (BH) in the appendices.

# Part II
# Findings

## 4 Physical Settings, Strata and Topography

The site is presently developed land bound by Centrum Boulevard along its south property line and by Brisebois Crescent along its north property line. Its

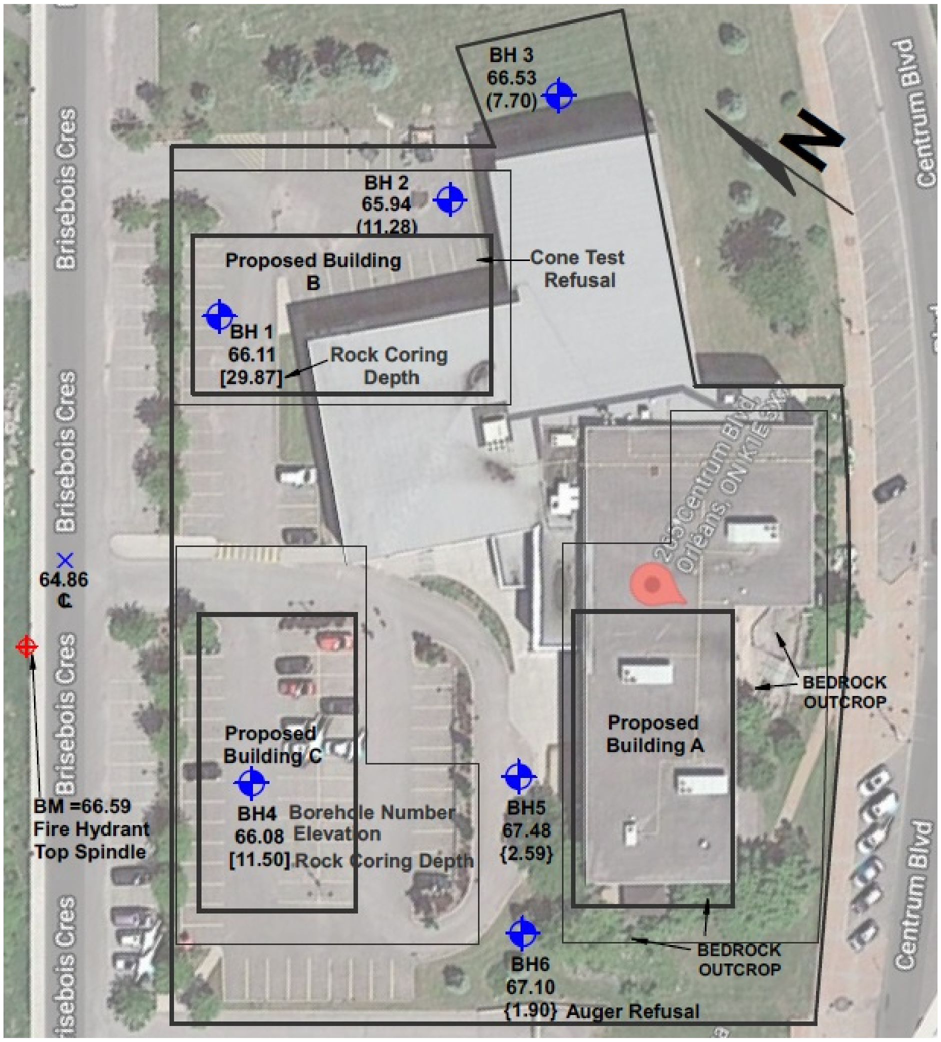

Figure 1: Test hole Locations Plan

ground surface descend roughly 5 m in elevation from Centrum Blvd to Brisebois crescent along a distance of roughly 100 m. Rock outcrops are prominently visible within the proximity of its south property line as shown in 1 in page 9.

Within the proximity of the north property line, rock coring is indicative of roughly 12 m depth of bedrock on the west side and up to 30 m depth of bedrock on the north east side. This transition of depth occurs within a horizontal distance of roughly 55 m. Auger and sampler refusals suggest shallower depths towards the bedrock outcrops existing along the south property line. The overburden materials were found to consist of stiff clay. Significant amounts of near surface fill were also sampled in the boreholes.

The geology data base by Belanger J. R. 1998 suggests 5 to 10 m of overburden soils underlain by limestone bedrock at this site.

# 5 Surface and Subsurface Materials

The arrangement of strata found in our investigation is shown in the borehole logs in appendix A. Generally, the site can be divided in areas where the soils are deep and where the bedrock is shallow. Where refusals are deeper than about 3 m the site is underlain by a silty clay deposit. Where the bedrock is less than about 3 m the materials found are fill of various types. The transition from shallow to deep is roughly south to north and more pronounced from south west to north east. Limestone bedrock was sampled in the two deeper boreholes along the north side of the property at 11.5 m and 30 m depth. Prove of bedrock depth in shallower boreholes was sought via sampler or auger refusal and ranged between 1.9 and 7.7 m. Soils at depths greater than about 6.7 to 14 m were tested via DCPT for estimation of mechanical properties. Refer to the borehole logs in appendix A for specific details.

## 5.1 Brown very silty clay

Silty clay deposits are typically overlain by a crust of brown very stiff silty clay as found in our boreholes. The strength of this clay is generally characterized by their shear strength via shear vanes and/or blow counts. Its shear strength is greater than 100 kPa.

## 5.2 Brownish Gray Silty Clay

The brownish gray silty clay is clay found below the water table. Its shear strength was found to range between 68 to 93 kPa via shear vane testing. Consideration of the strength of this clay represent the main limitation for bearing capacity of shallow foundations on soils and/or grade raise provided under this report.

Flow behavior in silty clays is generally controlled by its low $1 \times 10^{-6}$ cms/sec estimated permeability values. Inflow within excavations are thus expected to be low for this material.

## 5.3 DCPT Tested Strata

The mechanical properties to the 4.32 and 7.14 m depth of the DCPT tests completed in BH2 and BH3 can be estimated based on its results shown in the borehole logs in appendix A which have been used in combination with other field tests to determined the site class assigned in this report.

## 5.4 Limestone Bedrock

Several sampling core barrel runs were completed at 30 m depth. Due to undetermined reasons these runs recovered insufficient sample lengths to determine Rock Quality Designation (RQD) of the bedrock and other details at this depth. The core barrels were seen to find continuous resistance through the length of the runs. A single run of 1.52 m at 11.5 m depth is indicative of high quality limestone bedrock based on its 100% RQD. The bedrock is un-weathered and exhibit a degree of jointing with minimal separation as revealed by its RQD.

At the Centrum Blvd. located building entrance the bedrock was seen to consist of horizontally jointed un-weathered limestone with small separation through horizontal seams.

## 5.5 Groundwater and Moisture

The water level was measured on May 04, 2022 in a stand pipe installed in BH1 at 3.1 m depth. Ground water measurements in stand pipe installations often require numerous assessments in combination with borehole data.

Field observations of soils as extracted in the field in the sampler, measurements, coloration and stiffness suggest that the permanent water is at approximately 4.4 to 6 m depth and shown in the borehole logs. Moisture contents vary above the ground water table.

## 5.6 Freezing Index, Frost Depth and Frost Susceptibility

It is generally assumed that the frost depth for the 1,000 degree Celsius-days freezing index applicable to Ottawa will reach no deeper than 1.8 m on bare ground (snow free) or pavement. It is also assumed that frost depth will reach no deeper than 1.5 m on snow covered ground.

# Part III

# Recommendations

The following set of the recommendations result from sampling and testing outlined in section 3 and from geotechnical engineering evaluation and assessments.

It is understood that the proposed development will consist of a 3 high rise buildings with an at grade slab and no basement.

# 6 Foundations General

Generally speaking, code compliant Part 9 and Part 4 residential buildings founded on spread footings can be considered for the proposed 3 high rise buildings.

## 6.1 Load and Resistance Factors

For the purpose of computations related to the service (SLS) and strength limits (ULS) note:

- A resistance factor is applied to the computed or estimated (nominal) bearing resistance from field or lab tests to obtain the strength limit for factored loads (ULS). The value of the resistance factor is stated for each option.
- An average load factor of 1.5 is assumed to compute the service limit (SLS).

## 6.2 Bearing Capacity of Strip and/or Pad Footings

Bearing capacity for shallow spread footings foundations on sensitive silty clay deposits, having the conditions encountered at this site, is limited by the presence of soft to firm silty clay just below the crust and by the grade raise proposed in section 6.3. At this site, silty clay just below the crust was found to be stiff as determine from shear strengths shown in the borehole logs in appendix A.

Based on the findings of this investigation and geotechnical assessments, the following bearing capacity can be used *for strip footings up to 1 m wide and pad footings up to 2.5 m wide placed on undisturbed in situ soil*:

- 150 kPa at service limit (SLS).
- 225 kPa for factored loads (ULS).

After Peck, Ralph B. & Hanson, Walter Edmund. & Thornburn, Thomas Hampton. (1974)[2] for the near surface bedrock observed at this site and wherein discontinuities that are “tight or are not open wider than a fraction of an inch” the SLS bearing capacity below represent a 0.44 factor of the *allowable* bearing capacity for spread footings.

- 3.5 MPa at service limit (SLS).
- 5.25 MPa for factored loads (ULS).

After Peck, Ralph B. & Hanson, Walter Edmund. & Thornburn, Thomas Hampton. (1974)[3] for the bedrock sampled at 11.5 m depth having 100% RQD

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[2] Foundation engineering. New York : Wiley

[3] Foundation engineering. New York : Wiley

and wherein discontinuities that are “tight or are not open wider than a fraction of an inch” the SLS bearing capacity below represent a 0.19 factor of the *allowable* bearing capacity for spread footings.

- 6 MPa at service limit (SLS).
- 9 MPa for factored loads (ULS).

## 6.3 Restrictions for Grading/Terracing/Grade Raises

Grade raises are applicable in areas where the underlying materials consist of silty clay. Grade raises are established based on shear vane testing or consolidation testing, where greater accuracy is required. Along with these tests considerations of footing loads (section 6.2), founding depth and geometry are analysed to establish the maximum grade raise.

In order to determine grade raise at this site, shear vane[4] testing has been completed and shown in the borehole logs in appendix A. Based on assessments[5], analyses and safety factors, *1 m of grade raise*[6] *is assigned to this site.* Wherein the underlying materials consist of silty clay further increase of this grade raise can be considered if required for this development.

## 6.4 Settlements

For the footing loads provided in section 6.2 for silty clay, building settlements for foundations on undisturbed soils are not to exceed service limit values (SLS) of 25 mm and 20 mm total and differential settlements respectively at this site.

For the bearing capacities provided above settlement of foundations on bedrock will be negligible.

## 6.5 Deep Foundation Alternatives

For the scale of high rise buildings considered at this site load bearing strata will generally be the bedrock. Where the deepest levels of underground parking reside above the bedrock, load transfer to deep bedrock will thus be via structural elements suited to that end. Among alternatives to that end slurry walls along with bored piles and/or driven piles could be considered.

Driven piles on sloping bedrock can be conducive of numerous construction and design challenges. Some special pile tips have been developed to mitigate the challenges from sloping bedrock.

Slurry walls can be used as structural means to transfer loads to bedrock and as means to provide an impervious barrier along the perimeter of buildings. This make them well suited for buildings with underground parking. They have successfully been used in Ottawa. Slurry walls for these purposes are structural

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[4] Corrected after Bjerrum from Terzaghi, Peck and Messri (1996) at estimated 40% PI.

[5] Recommended Practice for Soft Ground Site Characterization: Arthur Casagrande Lecture

[6] The issue of grade raise has an important impact in developments.

diaphragm walls that extent into suitable strata or are socketed into the bedrock and whose construction take place before excavation. They are also used to shore up the perimeter.

Bored piles are drilled structural shafts embedded into the rock. Means to mitigate the challenges related to drilling through sloping bedrock are available for drilled shafts. The construction methods for these type of shafts make them better fit for application to sloping rock than driven piles.

### 6.5.1 Base Resistance by Correlations and/or Bearing Capacity Analysis

Piles are generally driven to refusal and/or drilled to bedrock and proof tested. The sound bedrock encountered in the boreholes will be competent to support deep foundation alternatives.

For pile foundations analysis involving piles embedded into the rock, high RQD values and 50 GPa Modulus of elasticity are acceptable for estimations at this time. Where the friction angle of the bedrock is required, use 30 degrees.

Base resistance from correlations with the information available at this time suggest 6 MPa and 9 MPa for service loads (SLS) as estimates for slurry walls and drilled shafts respectively at this time.

Specific geotechnical resistance for specific pile systems and locations will be provided if requested as part of this report.

## 6.6 Basement Waterproofing

For the subsurface conditions encountered hydrostatic pressure will build up along the perimeter of the underground parking of the building. Waterproofing is thus required.

The waterproofing system should be such to seal the building envelope by:

- where applicable, grouting bedrock joints along the perimeter of the building to a height 2 m above the ground water table;
- where applicable, providing a blind side waterproofing (or tanking) system such as Preprufe Plus® or similar as specified by the manufacturer;
- where applicable, a hybrid system including perimeter slurry walls;
- providing waterproof concrete;
- a redundant system providing one or more sealed sumps and pumps inside the building and drainage to catch any water which may breach the waterproofing system.

# 7 Site Class for Seismic Design

Site class will determine the design sideways acceleration from the earthquake envisioned as the local seismic hazard. A site class within the range of classes

A to F can be assigned at a site for any building depending on the soil and/or bedrock profile within a depth of 30 m from:

1. The underside of footings or
2. the underside of any pile caps in connection with deep foundation alternatives.

Shear waves are waves that are a component of the seismic waves induced by earthquakes and travel upward. What the soil profile defines is the magnitude and spectral content of the waves that reach the underside of foundations and/or any pile caps by means of the site class assignment. Standard geotechnical testing enable assignment of site classes C to F but not classes A or B. Site classes A or B can only be assigned via seismic tests.

The criteria to assign site class for seismic design under the Ontario Building Code 2012 (OBC 2012) is thus applicable at this site as follows:

1. any building whose footings sit directly on bedrock at this site can be design using site class C. This site class could be changed via a seismic test;
2. any building whose underside of pile caps sit within 6 m of the bedrock can be designed using site class C. This is based solely on applying the shear waves/soil profile averaging equation. A seismic test will be unable to change this site class;
3. any building whose underside of pile caps sit at height greater than 6 m from the bedrock can be designed using site class D. This is based solely on applying the shear waves/soil profile averaging equation. A seismic test will be unable to change this site class;

# 8 Roadbed Soils and Pavement Structure

The flexible pavement structures supplied in this report follow the guidelines set out in AASHTO 1993 Guide for Design of Pavement Structures (AASHTO) for climatic Region III. Under AASHTO pavements are designed to withstand 20 year accumulated design Equivalent Single Axle 80 kN (18,000 pounds) load applications (ESALs). ESALs are a measure of mix traffic loads including vehicle loads and truck loads. The number of ESALs applications depend on traffic class and use.

Generally, for low volume roads, the pavement structure to be placed on native soils or engineered roadbed at this site may consist of 400 mm of OPSS granular B, 150 mm of OPSS Granular A and up to 75 mm of asphalt.

For parking lots, pavement structure to be placed on native soils or engineered roadbed at this site may consist of 300 mm of OPSS granular B, 150 mm of OPSS Granular A and 50 mm of asphalt. This thicknesses will vary depending on expected traffic at different locations.

# 9 Excavations, Open Cuts, Trenches and Safety

Typically, the main concern when excavating soils or rock is the stability of the sides of excavations. The stability of the sides is achieved by either cutting the sides to safe slopes or by providing shoring. It is also an issue of safety because of imminent hazards to the safety of workers and to property. As such, excavations are governed by the provisions in the Occupational Health and Safety Act of Ontario (O. Reg. 213/91). The application of O. Reg. 213/91 requires a classification of soils in one or several of four types (type I to type IV).

At this site for soils can be considered type II under O. Reg. 213/91. As such, the following key aspects of O. Reg. 213/91 are applicable to excavations:

- Safe open cut is 1 vertical to 1 horizontal.
- Within 1.2 m of the bottom of open cut areas or trenches, the soil can be cut vertical.

Where the safe open cut is not provided, either the shoring systems described in O. Reg. 213/91 or engineered shoring systems need be used. Information regarding physical and mechanical properties of subsurface materials which will be required for shoring design are provided in this report.

## 9.1 Conditions Requiring Engineered Shoring

O. Reg. 213/91 describe the conditions in which engineered shoring systems are required. Some key aspects of O.Reg. 213/91 regarding the conditions in which an engineered shoring system is required are:

- Where soils are type I to III and the prescribed safe open cuts are not provided and
  - The excavation is not a trench or
  - The excavation is a trench either deeper than 6 m or wider than 3.6 m or both
- For trench excavations or open cut, where soils are type IV and the safe open cuts are not provided.

Note that along with the descriptions in O. Reg. 213/91 for soils type IV, any difficult soil having significant seepage and/or strength loss upon excavation such as caving soils can be rendered as type IV.

Note also that since excavation and safety are usually in control of the contractor, *shoring design and construction is done by the contractor.*

## 9.2 Construction and Excavation Along Adjacent Structures and Property Boundaries

Significant concerns regarding safety and property damage result from excavations along adjacent structures. O. Reg. 213/91 under "*Protection of Adjacent Structures*" establishes the following for excavations near adjacent structures:

- 229. (1) If an excavation may affect the stability of an adjacent building or structure, the constructor shall take precautions to prevent damage to the adjacent building or structure. O. Reg. 213/91, s. 229 (1).
- 229. (2) A professional engineer shall specify in writing the precautions required under subsection (1). O. Reg. 213/91, s. 229 (2).
- 229 (3) Such precautions as the professional engineer specifies shall be taken. O. Reg. 213/91, s. 229 (3).
- any comment and/or precaution and/o recommendation in this report is followed.

This section establishes the precautions required under O. Reg. 213/91 section 229 (2) above.

Excavation depths below the founding depth of adjacent structures will not take place, unless:

- Lateral support is provided to soils by cutting the slope to 1 horizontal to 1 vertical or
- lateral support is provided by shoring.
- any comment and/or precaution and/o recommendation in this report is followed.

It is also recommended that the edge of the 1 horizontal to 1 vertical slope providing lateral support be offset 0.3 m away from the edge of the foundation.

## 9.3 Comments on Excavations and Protection of Adjacent Structures

It is to be noted that since excavations and safety are controlled by the contractor, the design of shoring and structures to protect neighboring buildings are done by the contractors. This report is to provide recommendations for the excavations and information which will assist in the design of those structures.

The investigation findings suggests that there will be 0.8 to 2.9 m of overburden soils which will need to be cut to acceptable slopes or shored up. The bedrock could be cut vertical according to the findings in the boreholes.

Abutting the west boundary line, there is one level of underground parking and one storey above which appears to extend along the entire length of that boundary line according to rough measurements completed inside the said underground parking. The following scenarios could be considered for the conditions along the west boundary line subject to confirmations which will be completed at a later time:

1. that the building is founded on the bedrock;
2. that the building is founded on soils.

For scenario 1, the uncertainty remains about the capacity of the bedrock to bear the loads along the edge of the potential rock cut to be completed. To overcome this uncertainty, the installation of rock dowels prior to rock excavations or any other type of reinforcement can be considered to ensure safety for this structure. Dowels should be such to intercept any potential failure planes. Dowels that are inclined downward to the west at 25 degrees and that extend 4.5 m in length are thought to be capable of intercepting failure planes from what is found in this investigation. Assumptions for the design of dowels could be such to consider conservatively *smooth* failure planes. The properties reported here, along with the assumption of smooth planes appear to meet the requirements of the relationship in Spang and Egger (1990)[7] for rock dowels design.

For scenario 2, the soils will need to shored up and the bedrock will have to be provided with similar reinforcement.

# 10 Tree Planting

The section only applies to the site northerly one half paralell to Briscebois Crescent as clay is only present in that area.

Tree planting can be liable of damages to buildings and infrastructure. Sites where clay deposits are encountered are particularly more prompt to such potential damage. This is due to shrinkage of clays and silty clays induced by reduction of water content. Trees having greater water requirements should be avoided. As general guidelines tree planting should be reduced to species having low water requirements and heights at mature age. Hence, the following can be considered:

- Plant species having 10 m or less of mature height
- Use species having low water requirements
- Offset trees from buildings a distance equal to the mature height
- Space trees a distance equal to the mature height

The following can be considered as reference species acceptable at 6 to 8 m spacing as accepted at some locations where silty clays are encountered:

- Amur Maple
- Serviceberry
- Japanese Lilac
- Flowering Crab

Avoid the following species:

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[7] Spang, K. and Egger, P. (1990) Action of fully-grouted bolts in joined rock for fractured ground. J. Rock Mech. Rock Engng., 23, 210–99.

- Poplar
- Willow
- Eastern Cottonwood

Note that conifers have low water requirements

# 11 Water Inflow Within Excavations and Water Takings

Water inflow within excavations in soils is influenced by the depth of excavations relative to the water table and flow behavior of water in soils as controlled by the permeability of soils. Because of the assessments under sections 5 and 5.5 and information seen in the borehole logs, water inflow is expected to be low and controllable by pumping from open sumps.

### 11.0.1 Water Takings and Permits

Water takings from the environment, including groundwater in excavations, are regulated under Ontario Water Resources Act, R.S.O. 1990, c. O.40. (OWRA). The OWRA is enforced by the Ministry of Environment (MOE). Under the OWRA. a Permit to Take Water (PTTW) is required for pumping from excavations exceeding 400 cubic meters per day. Along with the consideration of ground water from excavations, PTTW applications require in addition the consideration of precipitation. The excavations at this site are subject to OWRA and this section is intended to provide criteria indicative of whether a PTTW may be required or not.

Given the size (area) of the proposed excavations, precipitation data in Ottawa and the soil conditions assessed under sections 5 and 5.5 pumping from excavations is not expected to exceed the threshold of 400 cubic meters per day so that *the requirement of a PTTW may not apply to the proposed development.*

Metered outlets must be maintained and recorded as proof for confirmation in case that OWRA requires it. Note that PTTWs are issued after months of the first filing of documents.

# 12 Underground Corrosion

For the resistivity, PH and soluble ions concentrations found at this site and shown in the Paracel Laboratories certificate of analysis in appendix B.1, the soils are very corrosive. Resistivity, PH and soluble ions testing was completed in a representative sample at 1.1 m depth in BH 3. After Romanoff (1957)[8], the following corrosion rates can be used:

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[8] Romanoff's work for the U. S. National Bureau of Standards is authoritative in underground corrosion

1. For carbon steel:
   - 45 $\mu$m/year for the first 2 years,
   - 30 $\mu$m/year, thereafter.
2. For galvanized metal:
   - 9 $\mu$m/year for the first 2 years,
   - 6 $\mu$m/year until depletion of zinc,
   - 30 $\mu$m/year for carbon steel.

# 13 Potential of Sulphate Attack to Concrete

For the sulphate content less than 0.1% in soil encountered at this site, there are no restrictions to the cement type which can be used for underground structures. This refers to restrictions associated with sulphate attack only.

# 14 Potential Impacts to Adjacent Structures

## 14.1 Impacts During Construction

The following impacts are foreseeable from the gotechnical stand point:

1. water table draw-down
2. blasting induced vibrations.

With regards to item 1, the building will be water proof. Pumping of ground water is limited to water that could breach the water proofing system. It is thus expected that the impact of the building to ground water conditions will be minimal. .

With regards to item 2, buildings are protected from vibrations damage by setting limits to the Peak Particle Velocities (PPV) measured using seismographs placed on the perimeter of the building. PPV is in units of mm/s. Research provided under the US Bureau of Mines in Report of Investigation RI 8507 (1989)A indicates a threshold limit PPV of 19mm/s at 40 Hz or less frequencies to adequately protect buildings. This reference value is not intended to overwrite the numerous regulations and/or bylaws the blasting contractor needs to abide to for blasting operations.

It is understood that at this time that the PPV thresholds applicable at this time in Ottawa are those set in table 1 under Ontario regulation OPSS.MUNI 120 copied in this report for ease of reference. Many other requirements under OPSS.MUNI 120 and other regulations apply.

| Element | Frequency (Hz) | PPV (mm/s) |
|---|---|---|
| Structures and Pipelines | <=40 | 20 |
| Structures and Pipelines | >40 | 50 |
| Concrete < 72 hours from placement | N/A | 10 |

Table 1: OPSS>MUNI 120 table 1 showing threshold vibration limits.

### 14.2 Impacts After Construction

The building will be water proof. Pumping of ground water is limited to water that could breach the water proofing system. It is thus expected that the impact of the building to ground water conditions will be minimal.

From the geotechnical stand point, Impacts other than the potential impact to ground water levels are not expected.

## 15 Stripping, Excavation to Undisturbed Soils and rock, Earth and Rock Fill Placement. Asphalt Placement and Compaction

Appendix C presents recommended geotechnical specifications and guidelines for stripping, earth excavation to undisturbed surfaces, earth and rock fill placement, asphalt placement, compacted lifts thicknesses for equipment type and compaction for different placements.

### 15.1 Winter Construction

In situ undisturbed materials consisting of brown clean sand and/or brown dense well graded sand and gravel encountered at this site are not sensitive to freezing temperatures. Construction during winter is still a challenging task due to the presence of frost, snow and ice. Snow and ice should be cleared from any geotechnical material present at this site prior to any backfill or placement of any structure. Concrete placement on frozen soils is not acceptable.

## 16 Responses to Requests from the City of Ottawa

This section provides information to amend this report in response to requests made by the City of Ottawa (C of O). The current request in question is: “MEMO / NOTE DE SERVICE; File No. D02-02-23-0021 & D07-12-23-0033” dated June 13, 2023 and it is in the form of the following numbered list:

D. Geotechnical Investigation:

D1. Please clearly specify the spacing between boreholes. Include discussion in the report and refer to Table 1 in the City of Ottawa Geotechnical Guidelines for the maximum allowable spacing between boreholes and test pits. Note that the Geotechnical Guidelines must be upheld and further boreholes would be required should required spacing not be met.

D2. Please include discussion on the choice of location of boreholes, including discussion and justification on the boreholes to which were halted prior to reaching the target depth of 10-15 meters for high-rise developments as per Table 2 of the Geotechnical Guidelines.

D3. Please discuss the potential impacts on adjacent properties in the body of the report.

D4. Please provide detailed discussion on recommendations for foundation design and foundation drainage including basement waterproofing and pumps, based on the geotechnical results.

D5. Please include discussion on any tree restrictions, as well as infiltration opportunities and its effect on the site.

D6. Please include discussion on the geotechnical impact on depth of services, cover, and other dimensions related to the services.

## 16.1 Response to D1 “Spacing of Boreholes”

YME does not generally have a section for Spacing of Boreholes or to discuss that. This section can only be found here.

Figure 2 in page 23 reproduces fig. 1 in page 9 with an added scale bar. It can be seen that the spacing meets the guideline of up to 50 m spacing between holes.

As the guideline must be “upheld” there is no possible outcome by discussing as it is all that matters.

## 16.2 Response to D2 “Location of Boreholes and Halted Holes”

YME does not generally have a section for Location of Boreholes and Halted Holes or to discuss that. This section can only be found here.

There are numerous considerations in the decisions leading to a final hole placement in the field. Proposed building footprint, goal for a particular hole or in general, sought information, type of proposed structure and actual space available in the field, buried utilities, proposed investigation budget, etc.

In general, probing bedrock and depth is an important goal at this site. Bedrock probing is generally accepted as a core run that is 1.5 m in length. When probing bedrock, holes are generally halted when the core run length is completed. It is unreasonable to continue coring to 15 m to meet an arbitrary guideline.

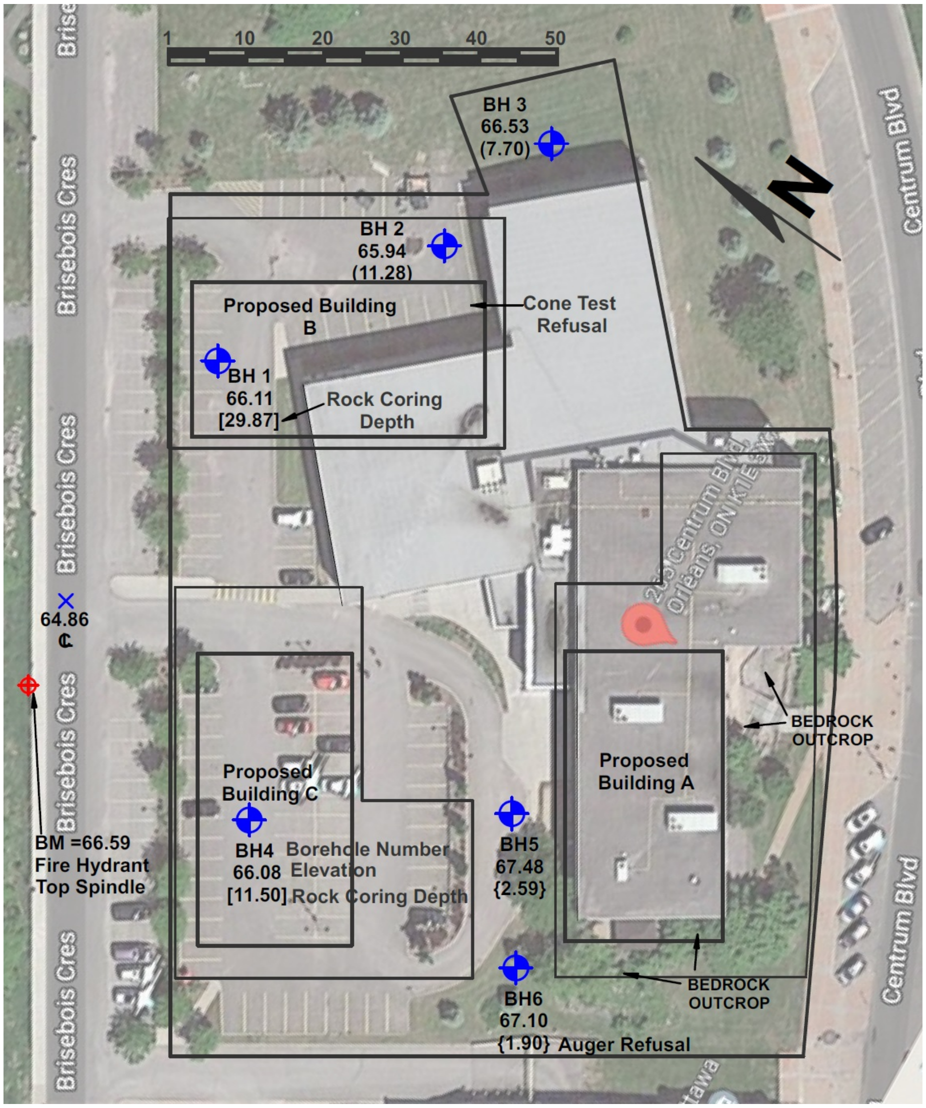

Figure 2: Test hole Locations Plan

In general field programs need to be flexible as it is never known what will be found during drilling. The example at this site, 30 m of drilling when 10 m was expected. 30 m of drilling may well take an entire day of drilling.

### 16.3 Respond to D3 “Impacts on Adjacent Structures”

A section has been added to the body of the report.

### 16.4 Response to D4 “Foundation design Discussion, Foundation Drainage and Waterproofing”

YME does not know what to add to the discussion that is already in the foundation and waterproofing sections. We are always open to answer specific questions.

### 16.5 Response to D5 “Tree Planting”

A tree planting section has been added to the report. The section only applies to the site northerly one half paralell to Briscebois Crescent as clay is only present in that area.

### 16.6 Response to D6 “Depth of Services, Cover and Dimensions”

YME does not generally limit those aspects. Services depths are generally restricted by the depth of City services that are already in place. Cover and dimensions are generally restricted by City Standars for placement of services, frost protection, clay seals, etc.

Clay seals are generally placed at 60 m spacing if the services are runnign through a clay profile.

## Disclaimer

Bayview Orleans Inc. BOI and other professionals understand that soils and groundwater information in this report has been collected in boreholes guided by standards and practice guidelines generally accepted for engineering characterization of ground conditions in Ontario and in no case borehole data and their interpretation warrant understanding of conditions away from the borehole locations. BOI accepts that as development will have spread away from the boreholes other designers will need the best opinion from the geotechnical consultant based on the findings of the investigation so that any statements which could be implicitly or explicitly depart from the conditions at borehole may be given to fulfill this need in good faith as best available opinion with the information available at the time without any warranties.

# User Agreement

## Acknowledgment of Duties

In this 54-BOI-R2 report, Yuri Mendez Engineering (YME) has pursued to fulfill every aspect of the obligations of professional engineers. As a part of those duties, from field work, operations, testing, analyses, application of knowledge and report, YME has ensured that it meats a high standard of Geotechnical engineering practice and care in the province of Ontario. Obligations under R.R.O. 1990, Reg. 941: Professional Engineers Act, R.S.O. 1990, c. P.28, further referred to as Reg. 941 which are of immediate interest to this service are:

"77. 7. A practitioner shall,

i. act towards other practitioners with courtesy and good faith,

ii. not accept an engagement to review the work of another practitioner for the same employer except with the knowledge of the other practitioner or except where the connection of the other practitioner with the work has been terminated,

iii. not maliciously injure the reputation or business of another practitioner,

8. A practitioner shall maintain the honour and integrity of the practitioner's profession and without fear or favour expose before the proper tribunals unprofessional, dishonest or unethical conduct by any other practitioner."

## Communications

54-BOI-R2 is to be used solely in connection with the 3 high rise buildings by Bayview Orleans Inc. (BOI) and thus subject of communications amongst other professionals (OP), government bodies and authorities, and BOI for that purpose. YME demands great care in precluding damage to the integrity of this professional work which may arise from careless communications from engineers of Canada. OP and BOI acknowledge understanding that where any such communication occur in connection with this report, they are bound by this agreement as an extension to the standard of care embodied in R.R.O. 1990, Reg. 941 and thus accept that any correspondence from OP or the public seen to add any bad connotations to the breadth, depth, typesetting, typography, formal semantics and scope of this report or otherwise diminish the breadth of services and knowledge delivered in this report which in any way raise concerns or insecurities to the qualities and/or the *reasonable completeness* delivered to BOI in this report will be forwarded to YME.

## Reasonable Completeness

OP and Bayview Orleans Inc. acknowledge understanding that said care and said standard has been applied equality to the reasonable completeness of this report relative to the information available from the field program and acknowledge understanding that is neither feasible nor possible to convey geotechnical information in this report that would cover for every possible consideration by OP and/or BOI and that upon issuance it will be subject to reviews which may trigger the need to add information which at the discretion of YME will be added when considered within the practice obligations under Reg. 941. The geotechnical information here provided is thus envisioned as to cover for the scope and breadth of design figures and assessments generally foreseeable as needed by other designers at the time of issuance and which could be amended as needed within the context of services provided by other designers. YME agrees to issue revised versions of this 54-BOI-R2 report by adding R# to each revision where # is the number of the revision. OP covenant to conduct all communications in connection with these reviews following great care to preclude the suggestion of a breach to the reasonable completeness acknowledged herein. Written communications which may trigger reviews under this agreement will be acknowledged as requests for "review under the 54-BOI-R2 report user agreement". This reasonable completeness is also relative to the scope of services generally accepted in geotechnical engineering work in Ontario

## Errors

Where errors are found during reviews under the 54-BOI-R2 report user agreement, OP covenant great care in communications to preclude the suggestion of a breach to the duties acknowledge herein which could induce damages to YME. Communications triggered by errors or any such communication which would render the person doing the request in a position of technical authority above the author implies an unauthorized review and constitute a serious breach of the code of ethics under Reg. 941 and damages to YME and so subject to disciplinary measures and/or liability for damages to YME. BOI is thus acquainted that correction of errors will be made and acknowledged by YME as they may arise in any professional work but in no way OP will purport or render such corrections as omissions departing away from the correction of errors set forth in this agreement. Where communications in connection with the correction of errors process set forth in this agreement raise concerns or insecurities to the qualities and/or the reasonable completeness delivered to BOI in this report occur, BOI covenants to inform YME. BOI is acquainted that such corrections are part of the natural processes associated with the applied sciences nature of this report and so typified explicitly in this agreement to protect YME from inappropriate manipulation of those processes by OP and others.

# Part IV

# Appendices

## A Borehole Logs

Report 54-BOI-R2
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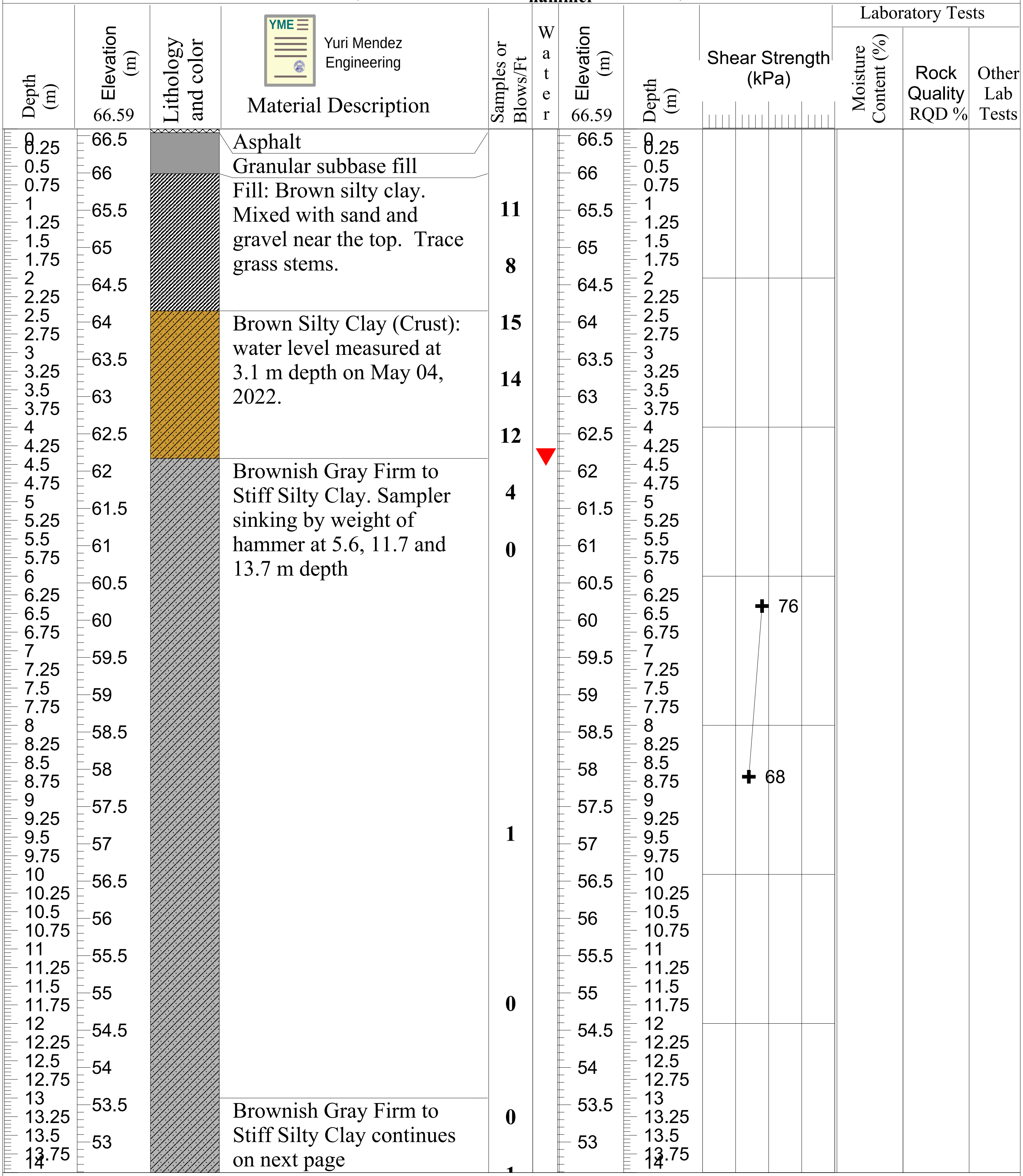
| | | |
|---|---|---|
| Project: **Proposed High Rise Buildings** | | YME Yuri Mendez Engineering. |
| Location: **265 Centrum Blvd.** | Client: **Bayview Orleans Inc.** | **Test Hole No.: BH1 of 6** |
| Job No.: **54-BOI** | Test Hole Type: **7" OD Auger.** | Date: **April 21, 2022** |
| "7" OD Auger." | SPT Hammer Type: **Safety auto hammer** | Logged By: **Yuri Mendez** |

Yuri Mendez Engineering



| Material Description | Blows/Ft |
|---|---|
| Asphalt | |
| Granular subbase fill | |
| Fill: Brown silty clay. Mixed with sand and gravel near the top. Trace grass stems. | 11<br>8 |
| Brown Silty Clay (Crust): water level measured at 3.1 m depth on May 04, 2022. | 15<br>14<br>12 |
| Brownish Gray Firm to Stiff Silty Clay. Sampler sinking by weight of hammer at 5.6, 11.7 and 13.7 m depth | 4<br>0<br>1<br>0 |
| Brownish Gray Firm to Stiff Silty Clay continues on next page | 0 |

S = Sample for lab review and moisture content

▼ Interpreted water level

| | | |
|---|---|---|
| Project: **Proposed High Rise Buildings** | | YME Yuri Mendez Engineering. |
| Location: **265 Centrum Blvd.** | Client: **Bayview Orleans Inc.** | **Test Hole No.: BH1 of 6** |
| Job No.: **54-BOI** | Test Hole Type: **7" OD Auger.** | Date: **April 21, 2022** |
| "7" OD Auger." | SPT Hammer Type: **Safety auto hammer** | Logged By: **Yuri Mendez** |

| Depth (m) | Elevation (m) 66.59 | Lithology and color | Yuri Mendez Engineering<br>Material Description | Samples or Blows/Ft | Water | Elevation (m) 66.59 | Depth (m) | Shear Strength (kPa) | Laboratory Tests: Moisture Content (%) | Laboratory Tests: Rock Quality RQD % | Laboratory Tests: Other Lab Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 14 – 28 | 52.5 – 39 | ▨ (14.0–14.2)<br>‖ (14.2–28) | Strata tested using Dynamic Cone Penetration Test (DCPT) | 1<br>1<br>2<br>1<br>2<br>1<br>2<br>3<br>6<br>3<br>2<br>3<br>3<br>4<br>4<br>3<br>4<br>4<br>7<br>6<br>5<br>7<br>6<br>11<br>8<br>9<br>9<br>8<br>14<br>14<br>12<br>12<br>9<br>14<br>17<br>14<br>15<br>12<br>53<br>45 | | 52.5 – 39 | 14 – 28 | | | | |
| | | | Strata tested using Dynamic Cone Penetration Test (DCPT) continues on next page | 39<br>40<br>38<br>40 | | | | | | | |

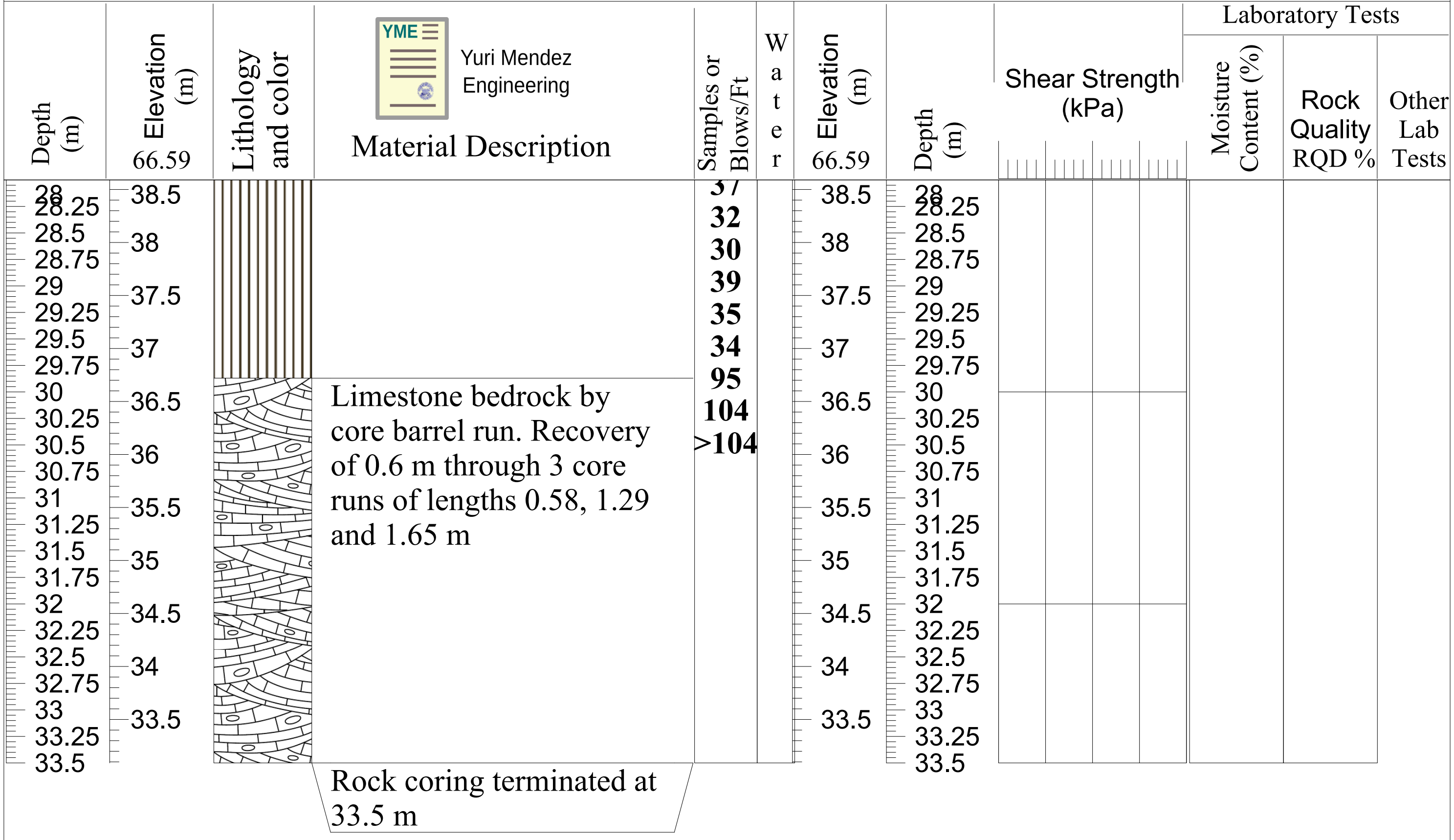
Depth scale (m): 14, 14.25, 14.5, 14.75, 15, 15.25, 15.5, 15.75, 16, 16.25, 16.5, 16.75, 17, 17.25, 17.5, 17.75, 18, 18.25, 18.5, 18.75, 19, 19.25, 19.5, 19.75, 20, 20.25, 20.5, 20.75, 21, 21.25, 21.5, 21.75, 22, 22.25, 22.5, 22.75, 23, 23.25, 23.5, 23.75, 24, 24.25, 24.5, 24.75, 25, 25.25, 25.5, 25.75, 26, 26.25, 26.5, 26.75, 27, 27.25, 27.5, 27.75, 28

Elevation scale (m): 52.5, 52, 51.5, 51, 50.5, 50, 49.5, 49, 48.5, 48, 47.5, 47, 46.5, 46, 45.5, 45, 44.5, 44, 43.5, 43, 42.5, 42, 41.5, 41, 40.5, 40, 39.5, 39

S = Sample for lab review and moisture content

🔻 Interpreted water level

| | | |
|---|---|---|
| Project: **Proposed High Rise Buildings** | | YME Yuri Mendez Engineering. |
| Location: **265 Centrum Blvd.** | Client: **Bayview Orleans Inc.** | **Test Hole No.: BH1 of 6** |
| Job No.: **54-BOI** | Test Hole Type: **7" OD Auger.** | Date: **April 21, 2022** |
| "7" OD Auger." | SPT Hammer Type: **Safety auto hammer** | Logged By: **Yuri Mendez** |



Limestone bedrock by core barrel run. Recovery of 0.6 m through 3 core runs of lengths 0.58, 1.29 and 1.65 m

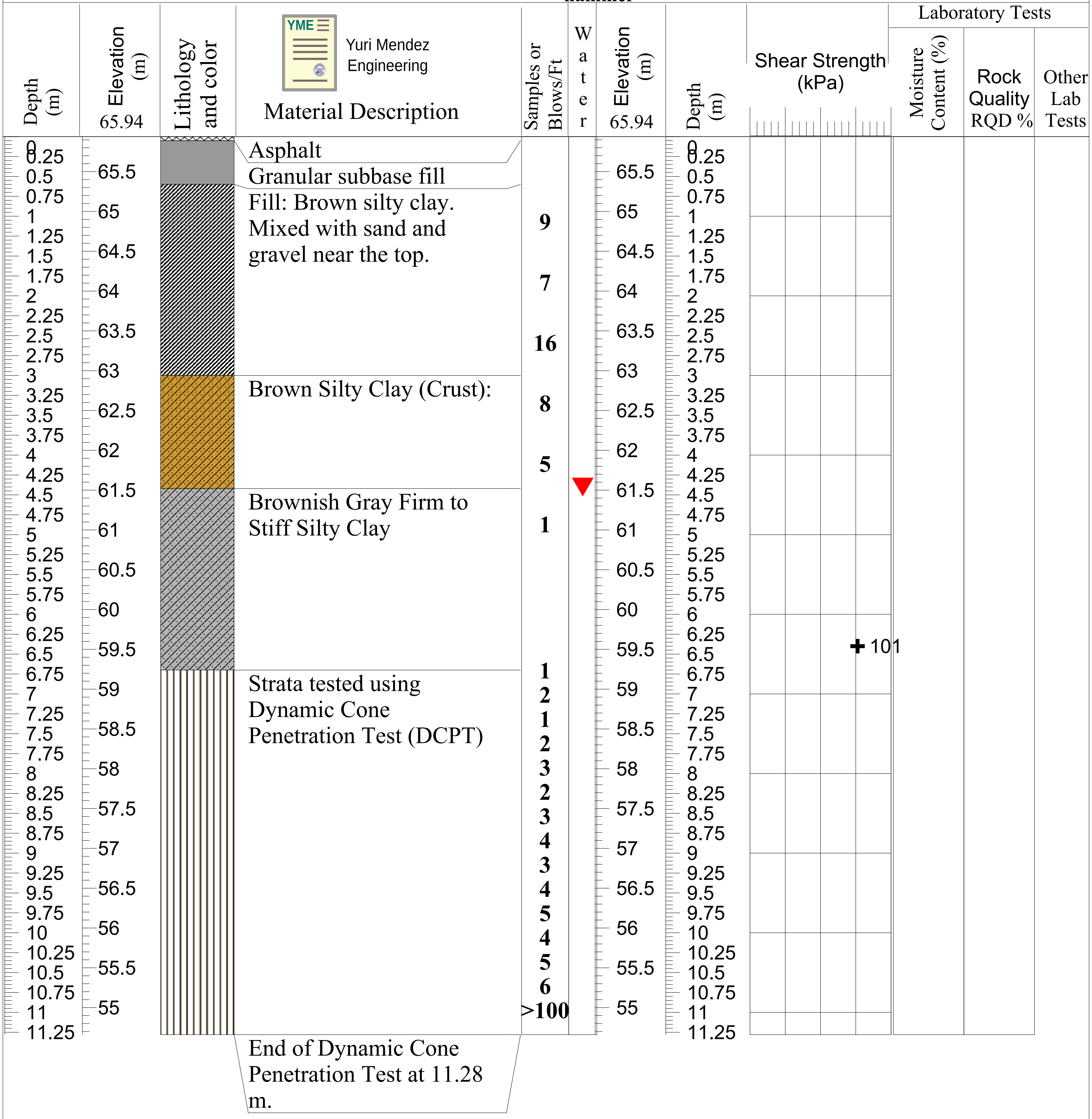
**37**
**32**
**30**
**39**
**35**
**34**
**95**
**104**
**>104**

Rock coring terminated at 33.5 m

S = Sample for lab review and moisture content

▼ Interpreted water level

| | | |
|---|---|---|
| Project: **Proposed High Rise Buildings** | | YME Yuri Mendez Engineering. |
| Location: **265 Centrum Blvd.** | Client: **Bayview Orleans Inc.** | **Test Hole No.: BH2 of 6** |
| Job No.: **54-BOI** | Test Hole Type: **7" OD Auger.** | Date: **April 21, 2022** |
| "7" OD Auger." | SPT Hammer Type: **Safety auto hammer** | Logged By: **Yuri Mendez** |



Asphalt

Granular subbase fill

Fill: Brown silty clay. Mixed with sand and gravel near the top.

Brown Silty Clay (Crust):

Brownish Gray Firm to Stiff Silty Clay

Strata tested using Dynamic Cone Penetration Test (DCPT)

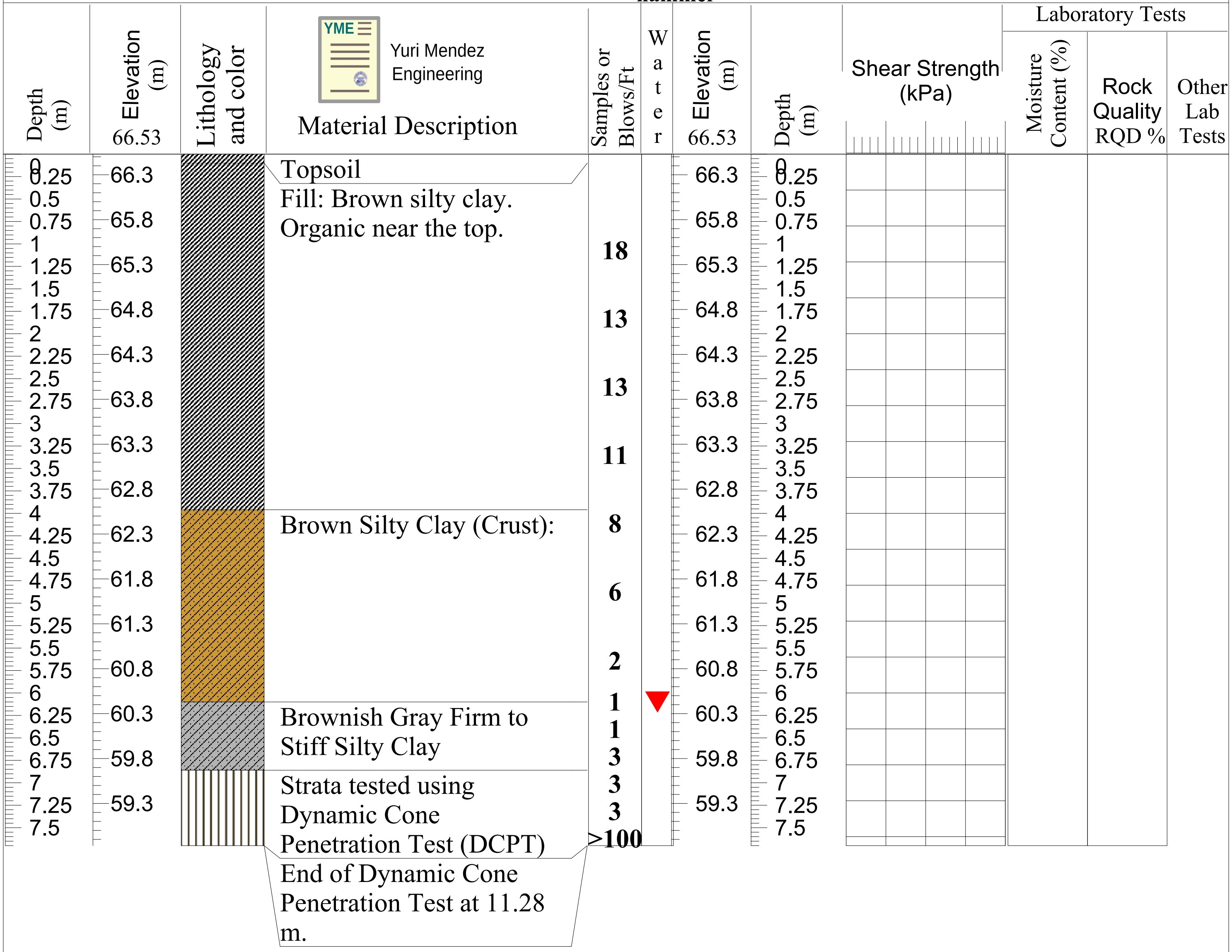
End of Dynamic Cone Penetration Test at 11.28 m.

Samples or Blows/Ft:
9
7
16
8
5
1
1
2
1
2
3
2
3
4
3
4
5
4
5
6
>100

S = Sample for lab review and moisture content

▼ Interpreted water level

| | | |
|---|---|---|
| Project: **Proposed High Rise Buildings** | | YME Yuri Mendez Engineering. |
| Location: **265 Centrum Blvd.** | Client: **Bayview Orleans Inc.** | **Test Hole No.: BH3 of 6** |
| Job No.: **54-BOI** | Test Hole Type: **7" OD Auger.** | Date: **April 21, 2022** |
| "7" OD Auger." | SPT Hammer Type: **Safety auto hammer** | Logged By: **Yuri Mendez** |



Topsoil

Fill: Brown silty clay. Organic near the top.

Brown Silty Clay (Crust):

Brownish Gray Firm to Stiff Silty Clay

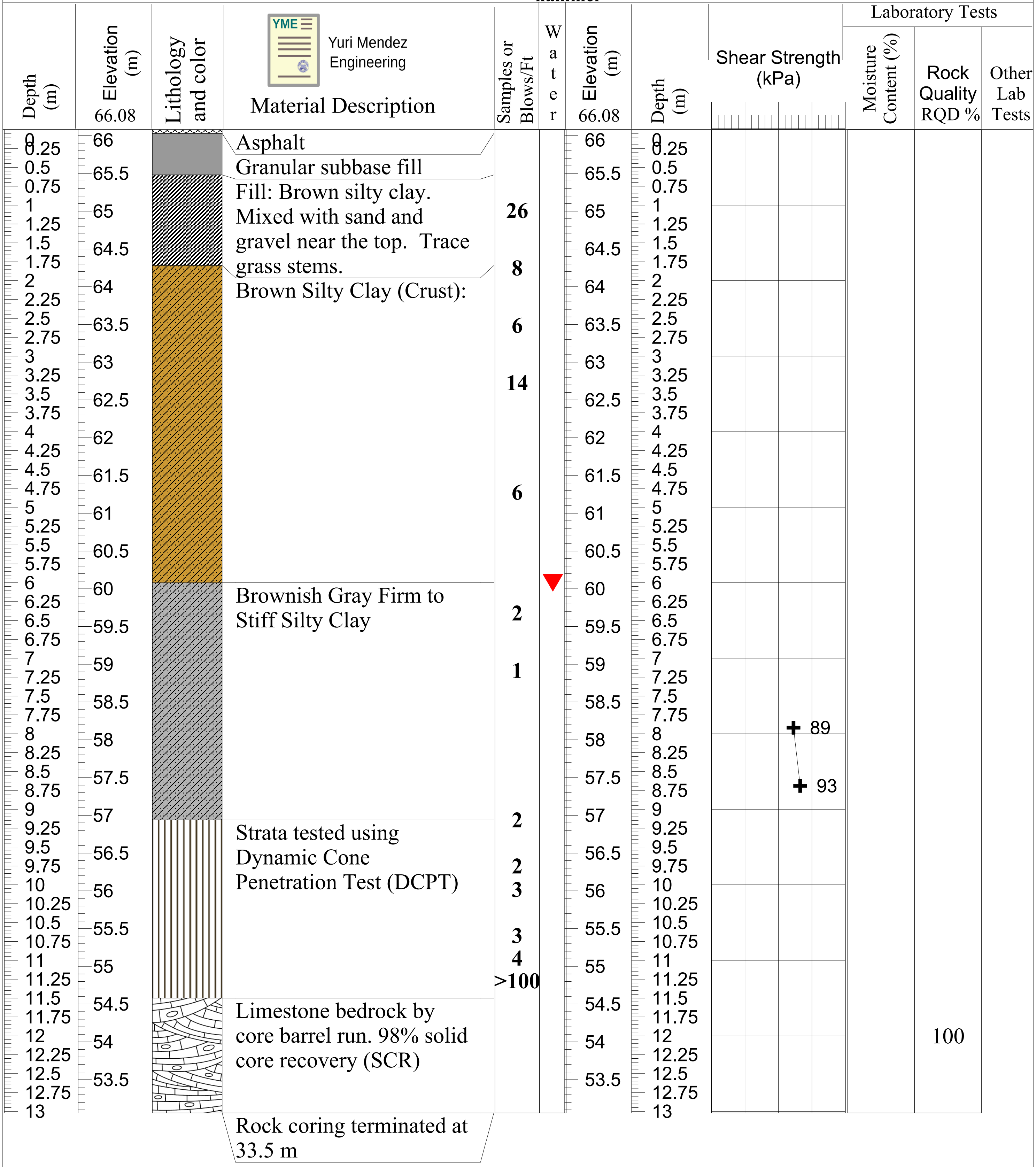
Strata tested using Dynamic Cone Penetration Test (DCPT)

End of Dynamic Cone Penetration Test at 11.28 m.

S = Sample for lab review and moisture content

▼ Interpreted water level

| | | |
|---|---|---|
| Project: **Proposed High Rise Buildings** | | YME Yuri Mendez Engineering. |
| Location: **265 Centrum Blvd.** | Client: **Bayview Orleans Inc.** | **Test Hole No.: BH4 of 6** |
| Job No.: **54-BOI** | Test Hole Type: **7" OD Auger.** | Date: **April 21, 2022** |
| "7" OD Auger." | SPT Hammer Type: **Safety auto hammer** | Logged By: **Yuri Mendez** |



Asphalt

Granular subbase fill

Fill: Brown silty clay. Mixed with sand and gravel near the top. Trace grass stems.

Brown Silty Clay (Crust):

Brownish Gray Firm to Stiff Silty Clay

Strata tested using Dynamic Cone Penetration Test (DCPT)

Limestone bedrock by core barrel run. 98% solid core recovery (SCR)

Rock coring terminated at 33.5 m

S = Sample for lab review and moisture content

▼ Interpreted water level

Project: **Proposed High Rise Buildings**

YME Yuri Mendez Engineering.

Location: **265 Centrum Blvd.**

Client: **Bayview Orleans Inc.**

**Test Hole No.: BH5 of 6**

Job No.: **54-BOI**

Test Hole Type: **7" OD Auger.**

Date: **April 21, 2022**

"7" OD Auger."

SPT Hammer Type: **Safety auto hammer**

Logged By: **Yuri Mendez**

Yuri Mendez Engineering

| Depth (m) | Elevation (m) 67.48 | Lithology and color | Material Description | Samples or Blows/Ft | Water | Elevation (m) 67.48 | Depth (m) | Shear Strength (kPa) | Laboratory Tests | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Moisture Content (%) | Rock Quality RQD % | Other Lab Tests |
| 0 | | | Asphalt | | | | 0 | | | | |
| 0.25 | 67.3 | ■ | Fill: Granular subbase | | | 67.3 | 0.25 | | | | |
| 0.5 | | ■ | | | | | 0.5 | | | | |
| 0.75 | 66.8 | ■ | | | | 66.8 | 0.75 | | | | |
| 1 | | ▨ | Fill: Brown silty clay mixed with granular material. | 46 | | | 1 | | | | |
| 1.25 | 66.3 | ▨ | | | | 66.3 | 1.25 | | | | |
| 1.5 | | ▨ | | | | | 1.5 | | | | |
| 1.75 | 65.8 | ▨ | | 10 | | 65.8 | 1.75 | | | | |
| 2 | | ▨ | | | | | 2 | | | | |
| 2.25 | 65.3 | ▨ | | | | 65.3 | 2.25 | | | | |
| 2.5 | | ▨ | | 13 | | | 2.5 | | | | |

Auger refusal

S = Sample for lab review and moisture content

▼ Interpreted water level

| | | |
|---|---|---|
| Project: **Proposed High Rise Buildings** | | YME Yuri Mendez Engineering. |
| Location: **265 Centrum Blvd.** | Client: **Bayview Orleans Inc.** | **Test Hole No.: BH6 of 6** |
| Job No.: **54-BOI** | Test Hole Type: **7" OD Auger.** | Date: **April 21, 2022** |
| "7" OD Auger." | SPT Hammer Type: **Safety auto hammer** | Logged By: **Yuri Mendez** |

| Depth (m) | Elevation (m) 67.1 | Lithology and color | Yuri Mendez Engineering<br>Material Description | Samples or Blows/Ft | Water | Elevation (m) 67.1 | Depth (m) | Shear Strength (kPa) | Laboratory Tests<br>Moisture Content (%) | Rock Quality RQD % | Other Lab Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0<br>0.25 | | ▨ | Topsoil | | | | 0<br>0.25 | | | | |
| 0.5<br>0.75 | 66.6 | ▨ | Fill: mixed clay, granular material,organic | | | 66.6 | 0.5<br>0.75 | | | | |
| 1<br>1.25 | 66.1 | ▨ | | 39 | | 66.1 | 1<br>1.25 | | | | |
| 1.5<br>1.75 | 65.6 | ▨ | | >100 | | 65.6 | 1.5<br>1.75 | | | | |
| | | | Auger refusal | | | | | | | | |

S = Sample for lab review and moisture content

▼ Interpreted water level

# Appendix

## B Resistivity, PH and Soluble Salts Test

Certificate of Analysis

**Client: Geoseismic**

**Client PO:**

Report Date: 06-May-2022
Order Date: 2-May-2022
**Project Description: 265 Centrum**

| | | | | | |
|---|---|---|---|---|---|
| | **Client ID:** | BH3 SS2 | - | - | - |
| | **Sample Date:** | 25-Apr-22 16:20 | - | - | - |
| | **Sample ID:** | 2219164-01 | - | - | - |
| | **MDL/Units** | Soil | - | - | - |
| **Physical Characteristics** | | | | | |
| % Solids | 0.1 % by Wt. | 69.5 | - | - | - |
| **General Inorganics** | | | | | |
| pH | 0.05 pH Units | 7.65 | - | - | - |
| Resistivity | 0.10 Ohm.m | 6.54 | - | - | - |
| **Anions** | | | | | |
| Chloride | 5 ug/g dry | 745 | - | - | - |
| Sulphate | 5 ug/g dry | 911 | - | - | - |

# Appendix

## C Construction Recommendations for Stripping, Earth and Rock Excavation to Undisturbed Soils, Earth and Rock Fill Placement, Asphalt Placement and Compaction

In the event that any of the following recommendations conflict with municipal and or provincial specifications, the most restrictive applies. For the case when products involving ground conditions are used, the manufacturer's specifications take precedence.

The contractor shall be prepared to proceed as directed by the geotechnical consultant within the framework of these recommendations. Construction methods will abide to these recommendations and/or be discussed and agreed upon with the consultant on site in real time or as expressed in writing.

### C.1 Field Briefings

At any time in which the geotechnical consultant is required in the field for inspections, the contractor shall brief the consultant in real time about any work in progress or work to proceed at the time requiring excavation, rock excavation, placement, hauling in or out, re-working, compaction equipment weight and nature, equipment passes, moisture, stock piling, sorting of materials, stock piling, etc. of geotechnical materials. The briefing will seek approval of the methods and materials and will involve discussions regarding the source, nature and/or specifications of any source of materials brought or removed, and/or placed and/or stock piled and/or excavated from the site and discussions to meet geotechnical requirements. The consultant may choose to instate a log book in the field which may include the persons having authority to log as representative of the contractor.

### C.2 Removal of Water

Removal and diversion of surface water and ground water will be planed prior to all earthwork within the scope of these recommendations. All surfaces in which to commence construction will be maintained dry and free of muddy conditions.

### C.3 Earth Excavation

Earth excavations are subject to the provisions in O. Reg. 213/91: Construction Projects under Occupational Health and Safety Act. Refer to section 9 for key aspect of O. Reg. 213/91 applicable to the findings in testholes at this site.

For the purpose of these recommendations earth materials will be refer to as one or more of the general material classes: topsoil and organic soils, non engineered fill, granular fill, native soils and rock. Topsoil and organic soils and non engineered fill are the subject of striping in subsection C.3.3.

#### C.3.1 Suitability of Earth Materials

The suitability of material for specific purposes is determined by the geotechnical engineer. To the extent they are needed, suitable material from the excavations can be used in the construction of required permanent earthfill or rockfill.

### C.3.2 Stockpiling and Sorting

Stockpiling is not an acceptable mean to build up the subgrade beneath the perimeter of structures of any kind. For stock piling, with the exception of native soils, material will be sorted in piles belonging exclusively to each material class. For native soils, sorting will be as determined by the geotechnical engineer. Mixed materials will be rendered unusable for uses other than the buildup of the subgrade in landscaped areas.

### C.3.3 Striping

Topsoil and/or organic soils and/or existing fill must be removed from the perimeter of all proposed structures, including retaining wall, buildings, pavement, parking areas and earth or fill banks for grading.

### C.3.4 Excavation to Undisturbed Soil Surface

All soil surfaces in which to commence construction for all structures are to be preserved in undisturbed condition (Undisturbed Soil Surface (USS)).

## C.4 Foundations Placement

Place foundations on undisturbed brown well graded dense sand and gravel that is not frozen.

## C.5 Imported Materials

Materials to be imported are subject to prior approval by the geotechnical engineer. The exceptions are granular materials having 12 % or less fines including clean sands. Fines are materials passing the # 200 sieve (70 $\mu m$).

## C.6 Overexcavation

Excavation in earth beyond the specified lines and grades shall be corrected by filling the resulting voids with approved, compacted earthfill.

## C.7 Earthfill

The type of Earthfill materials will be as indicated in plans and specifications. Suitability of earth materials will be determined by the geotechnical engineer.

Earthfill materials shall contain no frozen soil, sod, brush, roots, or other perishable material. Rock particles larger than 2/3 of the maximum approved lift thickness shall be removed prior to compaction of the fill.

For the purpose of this subsection all suitable materials will belong to one of the following two classes: *granular earthfill* and *select earthfill.* Granular eathfill will be any natural or crushed earth materials containing 12% or less passing the #200 sieve (70 $\mu m$). Select earthfill will be materials for which more than 12% passes the #200 sieve *and* have water content close to the optimum *and* have been rendered as suitable by the geotechnical engineer.

### C.7.1 Granular Earthfill Placement

#### C.7.1.1 Moisture for Granular Earthfill

For granular earthfill it is to be assumed that moisture will be added for placement. Compaction in wet of optimum condition is preferred for granulars.

#### C.7.1.2 Compacted Lifts Thicknesses Equipment and Passes for Granular Eathfill

Compacted lifts will not exceed 250 mm. Subject to test trials a maximum compacted lift of 300 mm may be accepted provided vibratory compaction equipment rated at 60,000 lb-f (27,300 kg-f) of dynamic force is used.

For road construction passes are to overlap by 300 mm for full coverage.

Where non vibratory pneumatic compactors with ballast an tire pressure of 100 psi (7 kg/cm2) are used (9 or 13 ply) the compacted lift thicknesses will not exceed 150 mm for granular.

For services and culvert trenches, when using rammers and light vibratory plates weighing less than 115 kg (250 lbs) the compacted lift thicknesses will not exceed 100 and 125 mm respectively. For heavier trench equipment the compacted lifts will not exceed 250 mm.

No heavy equipment will be operated above the crown of pipes or culverts unless 1.2 m of fill has been placed or the subgrade elevation has been reached.

For all trenches below the water table, trench foundation not less than 200 mm will be provided as per materials and specification in Table 2 in page 43.

Materials lift placement beneath foundations, slabs or any placement not specified above must abide to the above specifications as they relate to the equipment being used.

### C.7.2 Select Earthfill Placement

It is to be assumed that suitable select fill will be materials that will be excavated from the bank to be put directly on hauling equipment transported and dumped directly for spreading in lifts by push tractors, be added water and compacted. Stockpiling at the source or on site is not acceptable.

#### C.7.2.1 Moisture for Select Earthfill

It is to be assumed that moisture will be added for placement.

#### C.7.2.2 Compacted Lifts Thicknesses Equipment and Passes for Select Earthfill

Compacted lifts will not exceed 200 mm for heavy sheep foot rollers. Suitability of smooth vibratory rollers for the materials will be determined by the geotechnical engineer.

For road construction passes are to overlap by 300 mm for full coverage.

Where non vibratory pneumatic compactors with ballast an tire pressure of 100 psi (7 kg/cm2) are used (9 or 13 ply) the compacted lift thicknesses will not exceed 150 mm.

For services and culvert trenches, when using rammers and light vibratory plates weighing less than 115 kg (250 lbs) the compacted lift thicknesses will not exceed 100 and 125 mm respectively. For heavier trench equipment the compacted lifts will not exceed 200 mm.

No heavy equipment will be operated above the crown of pipes or culverts unless 1.2 m of fill has been placed or the subgrade elevation has been reached.

For all trenches below the water table, trench foundation not less than 200 mm will be provided as per materials and specification in Table 2 in page 43.

Materials lift placement beneath foundations, slabs or any placement not specified above must abide to the above specifications as they relate to the equipment being used.

### C.7.3 Compaction Guide for Passes and Level of Compaction

The contents of this section are provided as guidelines for construction. The resulting compaction densities and compacted lift thicknesses can only be verified by actual testing and field trials respectively.

For equipment passes the contractor may consider not less than 4, 5 or 6 passes for 95, 98 or 100 % Proctor Standard compaction.

For granular materials loose lifts may be approximately 150, 175 and 235 mm for compacted lift thicknesses 125, 150 and 200 mm respectively.

For select earthfill materials loose lifts may be approximately 125 and 190 mm for compacted lift thicknesses 100 and 150 mm respectively.

## C.8 Compaction General

It is to be assumed that water will be added for compaction and that the required maximum grain size shall be 3/4 of the compacted lift thickness.

Obtain the approximate loose lift thickness by dividing the compacted lift by 0.88. Compacted lifts are approximately 12% less than the loose lift thickness.

Each lift shall be compacted by the specified number of passes of the approved type and weight of roller or other equipment.

Table 2 in page 43 presents Proctor Standard (PS) compaction requirements for specified placement and materials.

## C.9 Compaction Specific

### C.9.1 Compaction Along Basement Walls, Retaining Walls and Structures

No heavy compaction equipment is to be operated within 0.9 m of any structure. The consolidation zone is defined as the zone within 0.9 m of the exterior edge of basements or the interior edge of retaining walls or any structure. Only light to very light compaction is to be applied along the consolidation zone with no more than 2 passes of light vibratory equipment.

### C.9.2 Self Compacting Materials

There are no self compacting materials. Total fill thickness of 200 mm of granular materials consisting of more than 90% of one nominal size referred to as crushed stone are acceptable without compaction under concrete slabs.

### C.9.3 Settlement Allowance and Overfill

The settlement (consolidation) of lightly compacted earthfill can be excessive. Overfill to compensate for settlement allowance will be discussed with the geotechnical engineer.

### C.9.4 Compaction Quality Control

Provide moisture density relationships for Standard Proctor compaction for the proposed materials and source. Conduct one in situ test at randomly selected locations per 60 m3 of fill. This is approximately one test, each 300 m2 of lift in place. Nuclear or non-nuclear density probes testing can be used. Density probes will only measure the density within 0.12 m depth at the point of the measurement.

## C.10 Asphalt Pavement

Place asphalt mix only when base course, or previous course is dry and air temperature is 7 degrees C and increasing.

Asphalt pavement mix temperatures at the time of placement will be within the range of 120 to 160 degrees C.

Do not place asphalt on a surface which is wet or covered by snow or ice or if the ground is frozen.

| Material Placement | Material Description | % PS |
|---|---|---|
| Base | OPSS.MUNI 1010 Granular A | 100 |
| Subbase | OPSS.MUNI 1010 Granular B Type II | 100 |
| Subgrade | Granular earthfill (with 12 % or less fines) and 100% passing 106 mm sieve | 95 |
| | Select earthfill | 95 |
| Backfill for trenches under pavement | Granular earthfill (with 12 % or less fines) and 100% passing 106 mm sieve. | 95 |
| | Select earthfill | 95 |
| Under sidewalks top 200 mm | Any OPSS.MUNI 1010 Granular specification for which 100% passes the 26.5 mm sieve | 95 |
| Under foundations | OPSS.MUNI 1010 Granular B type 2 with 12% or less fines and for which 100% passes the 106 mm sieve | 98 |
| Backfill under slabs on grade | Cohesionless (with 12 % or less fines) and 100% passing 106 mm sieve. | 100 |
| | Select earthfill | 100 |
| Top 100 mm under slabs | Crushed stone 9.5 to 19 mm (use one or several sizes). | 90 |
| Pipe bedding and cover (150 mm for bedding to 150 mm above the crown) | Any OPSS.MUNI 1010 Granular specification for which 100% passes the 26.5 mm sieve | 95 |
| Trench foundation (stabilization minimum 200 mm) | Any OPSS 1010.MUNI Granular specification for which 100% passes the 106 mm sieve except Granular B Type I | 95 |
| Backfill for non building, non traffic and/or non parking areas | Granular (with 12 % or less fines) and 100% passing 106 mm sieve | 90 |
| | Select earthfill | 90 |
| Placement not specified above | Granular (with 12% or less fines) and 100% passing 106 mm sieve | 95 |
| | Select earthfill | 95 |

Table 2: Proctor Standard (PS) compaction requirements for specified placement and materials.

### C.10.1 Surface Preparation for Asphalt Pavement

It is to be assumed that rough grading and fine grading shall take place before asphalt placement. Rough grading will be completed to within ± 25 mm of the underside of asphalt and tested to meet the specified density. Fine grading and rolling will completed by the paving contractor. The granular material for fine grading will meet OPSS.MUNI 1010 Granular M.

### C.10.2 Proof Rolling Prior to Asphalt Pavement

Conduct proof rolling using a single pass of a tandem-axle dump truck or a tri-axle dump truck with the third axle raised loaded to a minimum gross vehicle weight of 26 metric tons at walking speed. Rutting in excess of 25 mm is considered failure. Where proof rolling reveals areas of defective subgrade, Remove base, Sub-base and subgrade material to depth and extent and width that will allow reconstruction using the available equipment or as directed by the Consultant.

### C.10.3 Asphalt compaction

The compacted lifts are accepted to be 80% of the loose lift thickness (the loose lift reduces thickness by 20% when compacted). Divide the compacted lift thickness by 0.8 to obtain the thickness of the loose lift.

Compaction will consist on at least three passes at approximately walking speed (5.4 km/hr) as follows: *break down rolling* using a vibratory steel drum roller, *intermediate rolling* with a static (non-vibrating) roller or a pneumatic roller and *finish rolling* with a smooth static roller.