



FINAL REPORT

FOUNDATION INVESTIGATION AND DESIGN REPORT **Roadway Protection Systems for Rehabilitation of Taylor Road Underpass,** **Highway 11, Site No. 42-182, Bracebridge, Ontario**

Agreement No. 5013-E-0008
Assignment No. 12
GWP 5294-11-00
Geocres No. 31E-359

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Ministry of Transportation

Foundation Investigation and Design Report

Agreement No. 5013-E-0008

Assignment No. 12

GWP 5294-11-00

Geocres No. 31E-359

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Project Name:

Foundation Investigation and Design for Roadway Protection Systems for rehabilitation of Taylor Road Underpass, Site No. 42-182, HWY 11, Town of Bracebridge, District of Muskoka

Project Number:

ADM-00028245-N0

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1 FOUNDATION INVESTIGATION REPORT

1.1 Introduction

This foundation investigation report presents the results of a geotechnical investigation completed by **exp** Services Inc. for the roadway protection system for rehabilitation of Taylor Road underpass at Hwy 11, Town of Bracebridge, District of Muskoka, the Ministry of Transportation (MTO) Northeastern Region. The work was undertaken under Agreement # 5013-E-0008, Assignment No. 12 (GWP 5294-11-00). The terms of reference (TOR) were as presented in the MTO letter dated November 26, 2015. The General Arrangement (GA) drawing for the underpass bridge prepared by Morrison Hershfield Ltd. was provided to **exp** by MTO.

The purpose of the investigation is to determine the subsurface conditions within the vicinity of proposed roadway protection for the Taylor Road underpass rehabilitation. The site specific geotechnical investigation consisted of borings, soil sampling, borehole logging, and laboratory testing.

This foundation investigation report has been prepared specifically and solely for the project described herein. It contains the factual results of the investigation and the laboratory testing completed for this project.

1.2 Site Description and Geological Setting

1.2.1 Site Description

The Taylor Road underpass is located on Hwy 11, Station 12+601.181, Town of Bracebridge, District of Muskoka. The site plan and cross-section profile for the Taylor Road Underpass are shown in Drawing 1 in Appendix B. Photographs of the existing site/bridge are included in Appendix A.

At the site location, Taylor Road is two lanes. The roadway and shoulders are paved on both side of road. In the TOR, it is noted that the underpass bridge was originally constructed in 1987. It is a two span bridge with post-tension concrete deck with round voids, and is about 80 m in length and about 10.9 m wide. The approaches are provided with guardrails on both sides of roadway.

The general site conditions were assessed during the drilling operations conducted between December 17 and 18, 2015. The surrounding terrain is sloping west to east, grass covered, treed areas with mostly coniferous trees and well- drained. Selected photographs are provided in Appendix A.

1.2.2 Geological Setting

In accordance with the Ministry of Northern Development and Mines Map 2556, Quaternary Geology of Ontario, Southern Sheet, the site is generally glaciofluvial outwash deposits consisting of gravel and sand including proglacial river and deltaic deposits.

In accordance with the Ministry of Northern Development and Mines Map 2544, Bedrock Geology of Ontario, Southern Sheet, the bedrock at the site consists of migmatitic rocks and gneisses of undetermined protolith.

1.3 Site Investigation Procedures

1.3.1 Field Work

The field work for this project was carried out between December 17 and 18, 2015. The investigation consisted of a total of 2 sampled boreholes (BH1 and BH2). The boreholes were advanced from the embankment crest within the existing roadway. Boreholes BH1 and BH2 were drilled through roadway close to the west abutment and east abutment, respectively, and were advanced to a depth of 9.8 m below the ground surface. The borehole locations are shown on Drawing 1 in Appendix B.

The boreholes were advanced using a Mobile CME-55 truck mounted drill rig, equipped with a hollow stem auger and standard soil sampling equipment operated by a specialist drilling contractor, Marathon Drilling Co. Ltd.

The borehole locations (referenced to the MTM NAD83 coordinate system) and their ground surface elevations were surveyed by **exp** personnel using the Trimble GPS. These temporary collected data were compared and found consistence with the data presented in the GA drawing.

During the drilling of the boreholes, soil samples were obtained using a 51 mm outside diameter (O.D.) split-spoon sampler in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586) at intervals ranging from 0.75 m to 1.5 m in depth as shown on the attached borehole logs (Appendix C). The original field (uncorrected) SPT “N” values were recorded on the borehole logs as recommended in the Canadian Foundation Engineering Manual (CFEM, pg. 40) and used to provide an assessment of in-situ consistency or relative density of non-cohesive soils.

Upon completion of the boreholes, ground water level measurements were carried out from the boreholes in accordance with the Ministry of Transportation guidelines. The measured ground water levels after completion of drilling boreholes were recorded on borehole log sheets in Appendix C. The boreholes were decommissioned by backfilling with bentonite/cement mixtures in accordance with the Ministry of the Environment Regulation 903, as amended by Regulation 128/03 (the well regulation under the *Ontario Water Resources Act*).

The fieldwork was supervised by members of **exp**'s engineering staff who directed the drilling and sampling operation, logged borehole data in accordance with MTO and/or ASTM Standards for Soils Classification, and retrieved soil samples for subsequent laboratory testing and identification.

All of the recovered soil samples were placed in labelled moisture-proof bags, and returned to **exp's** Brampton laboratory for additional visual, textual and olfactory examination.

1.3.2 Laboratory Testing

All samples returned to the laboratory were subjected to visual examination and classification. The laboratory testing program included the determination of natural moisture content, particle size distribution test for approximately 25% of the collected soil samples. All of the laboratory tests were carried out according with MTO and/or ASTM Standards, as appropriate.

The laboratory test results are provided on the attached borehole log sheets in Appendix C. The results of the grain size analyses are presented graphically in Appendix D.

1.3.3 Previous Investigation

One foundation report is available in the MTO GEOCREs library for this particular site.

- 1 Foundation Investigation Report for Taylor Road Interchange Underpass, WP 33-77-02; Site 42-182; Hwy 11, District 11, Huntsville, Geocres No. 31E-92; MTC, April 1979.

1.4 Subsurface Conditions

The detailed subsurface conditions encountered in the boreholes advanced during this investigation are presented on the borehole log sheets in Appendix C. Laboratory test results are provided in Appendix D. The "Explanation of Terms Used in Report" preceding the borehole logs in Appendix C forms an integral part of and should be read in conjunction with this report.

A borehole location plan and cross sections of subsurface profiles are provided in Appendix B (Drawings 1). It should be noted that the stratigraphic boundaries indicated on the borehole logs, and the cross section stratigraphic profiles are inferred from non-continuous sampling in boreholes, observations of drilling progress, and results of Standard Penetration Tests. These boundaries typically represent transitions from one soil type to another and should not be regarded as exact planes of geological change. Furthermore, subsurface conditions may vary between and beyond the borehole locations.

In general, the subsurface conditions within the proposed roadway protection sites consist of sand fill followed by native sand. A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

1.4.1 Asphalt

Asphalt was encountered at the surface of both boreholes (BH1 and BH2). The thickness of the asphalt layer is about 150 mm. Asphalt thicknesses may vary beyond the borehole location.

1.4.2 Fill: Sand

Sand fill was encountered below the asphalt layer in both boreholes. The fill layer was encountered at a depth of 0.2 m below ground surface (Elev. 286.9 m and Elev. 286.8 m) at BH1 and BH2 respectively and extended to a depth of approximately 5.3 m below ground surface (Elev. 281.7 m). The explored thickness of this fill layer was about 5.0 m.

The composition of the fill layer is mostly sand trace gravel, trace to few silt. The material is brown to greyish brown and moist. The SPT "N" values within this fill layer ranged from 4 to 74 blows per 300 mm penetration, suggesting a very loose to very dense compactness condition. One SPT "N" value of 50 blows per 100 mm was recorded in BH2, the higher value could be influence of gravel.

Laboratory testing performed on selected samples consisted of moisture content and grain size distribution tests. The test results are as follows:

Moisture Contents:

- 2.1% to 10.3%

Grain Size Distribution:

- 3% gravel;
- 88% to 92% sand; and
- 5% to 9% silt and clay

The results of the moisture content and grain size distribution tests are provided on the record of borehole sheet in Appendix C. The results of the grain size distribution tests are also provided on Figure 1 in Appendix D.

1.4.3 Sand

A native sand layer was encountered below the sand fill layer. The sand deposit was encountered at a depth of approximately 5.3 m below ground surface (Elev. 281.7 m) and extended to depth explored of 9.8 m below ground surface (Elev. 277.1 m). The explored thickness of this deposit was about 4.6 m. Both boreholes were terminated within this layer.

The composition of this layer is mostly sand, trace to little gravel, trace silt, trace clay and trace rootlets. The material is brown to greyish brown and moist to wet. The SPT "N" values within this layer typically ranged from 22 to 54 blows per 300 mm penetration, suggesting a compact to very dense compactness condition. One SPT "N" value of 6 blows per 300 mm was recorded in BH 1, the lower value could be influence of the thin clayey silt layer encountered.

Laboratory testing performed on selected samples consisted of moisture content and grain size distribution tests. The test results are as follows:

Moisture Contents:

- 3.0% 21.4%

Grain Size Distribution:

- 1% to 13% gravel;
- 69% to 84% sand;
- 3% to 27% silt and
- 11% clay

The results of the moisture content and grain size distribution tests are provided on the record of borehole sheet in Appendix C. The results of the grain size distribution tests are also provided on Figure 2 in Appendix D.

1.5 Ground Water Conditions

Information of groundwater levels at the site was obtained by measuring the water levels in the open boreholes after completion of drilling. The groundwater levels encountered in the boreholes are shown on the borehole logs. Upon completion of boreholes, the water level in BH2 was 9.6 m below the ground surface (Elev. 277.3 m), while BH1 was dry.

Water levels measured in open boreholes might not be stabilized due to short term observation. However, based on moisture content of the soil samples observed during drilling and measured subsequently in the lab, the inferred ground water level within the embankment was estimated to be at approximate Elevation of 277.3 m or slightly higher at the time of the investigation. Seasonal variations in the water table should be expected, with higher levels occurring during wetter periods of the year and lower levels during drier periods.

2 ENGINEERING DISCUSSIONS AND RECOMMENDATIONS

This section of the report provides geotechnical design recommendations on roadway protection systems for rehabilitation of Taylor Road Underpass at Hwy 11, Town of Bracebridge, District of Muskoka. The recommendations are based on an interpretation of the factual data obtained from the boreholes advanced during the current investigation at the site and presented in Part I- Foundation Investigation Report. The interpretation and recommendations provided are intended solely to permit designers to assess temporary protection systems alternatives for bridge rehabilitation. Comments on construction are only provided to highlight issues that could affect the design. Contractors bidding on the works should make their own assessments of the factual data and how it might affect construction means and methods, scheduling and the like.

This report addresses the geotechnical design of the foundation for the roadway protection system by providing geotechnical design parameters that may be required in accordance with the latest edition of the *Canadian Highway Bridge Design Code (CHBDC)* (CAN/CSA-S6-14), the *Canadian Foundation Engineering Manual (CFEM)* (2006), Pertinent construction issues from a geotechnical standpoint are examined in general accordance with the Terms of Reference from MTO Letter dated November 26, 2015.

2.1 General

It is understood that the existing Taylor Road underpass bridge, located at Hwy 11, Station 12+601.181 in Township of Bracebridge will be converted to a semi-integral abutment configuration, which will involve the removal of approach slabs and expansion joints. It is anticipated that this work will require excavations of the embankment fills immediately behind the abutment walls to facilitate the rehabilitation work. The depth of excavation behind the ballast wall is expected to be about 3.1 to 3.5 m.

Based on subsoil conditions encountered at the site it is expected that excavation will be carried out through sand to silty sand fill and native sand. The subsurface conditions at the west approach embankment encountered in BH1 below the asphalt layer, generally consists of 5.3 m of sand fill underlain by a stratum of native loose to dense sand. At the east approach embankment similar soil layers are encountered in BH2; i.e. a 5.2 m thick layer of sand fill below the asphalt, followed by native compact to very dense sand. Both boreholes were terminated in the native sand layer at about 9.8 m depth.

The “non-stabilized” water level upon completion of drilling was measured at a depth of 9.6 m below the roadway surface in BH2 corresponding to Elevation 277.3 m, while BH1 was dry. Stabilized water levels may be slightly higher as indicated in a previous section. Therefore, it is not expected that groundwater will be encountered during the excavation. However, the groundwater level may vary at the time of year that the rehabilitation works are carried out. Perched groundwater may be present within the granular fill layers as well. Surficial water seepage into the excavations should be expected especially during the periods of heavy precipitation. Properly filtered sump

pumps at the bottom of excavation may be required to provide groundwater control and the pumping should be located outside of the actual excavation zone for the rehabilitation works. Surface water runoff should be controlled and directed away from the excavations during the construction.

2.2 Excavations and Temporary Cut Slopes

All excavation activities must be carried out in accordance with the Ontario Occupational Health and Safety Act (OHSA) and Regulations for Construction Projects (O. Reg. 213/91). Excavation safety and stability of temporary construction slopes and lateral support systems are the Contractor's responsibility.

The sand to sandy silt fill and native sand, below the pavement structure and approach slabs, are considered Type 3 soils in accordance with the OHSA and Regulations for Construction Projects, as such, side walls of temporary open excavations, above the water table, would have to be cut back to an angle of 1H:1V to remain stable. Locally within any zone of seepage from perched water, sloughing to slightly flatter angles might occur. At the bridge approach, a vertical excavation, parallel to the active traffic line, is required to carry out the excavation below modification of the ballast walls. Therefore, a roadway protection system will be required perpendicular to both abutments.

Excavated soil should be placed well away from the edge of the excavation and their height should be controlled so they do not surcharge the sides of the excavation. Note that the excavated soils are subject to moisture content increase during wet weather conditions which may render these materials too wet for adequate compaction. Stockpiles should therefore be compacted at the surface or be covered with tarpaulins to help minimize moisture ingress.

2.3 Roadway Protection System

Roadway protection system construction is required to facilitate the rehabilitation work. To safely support the excavation walls and minimize the impact to existing utilities in the embankment (if any), temporary shoring consisting of driven steel piling or soldier H-pile with lagging, should be practical options at these locations. Subsurface conditions at this site are suitable for both of these options. Where the depth requiring support is too much for cantilevered systems, bracing in the form of rakers anchors or deadman can be considered. A comparison of these two systems based on advantages and disadvantages, risks and relative costs is provided in Table 2.1.

It is considered that a sheet pile of sufficiently robust cross section could be driven through granular fill and natural deposits at the site. Difficulties with installation may occur where occasional boulders (if any) are encountered in the fill, requiring their removal before further driving. Alternatively, an H-pile with lagging wall can be used as a vertical temporary shoring system. The H-piles are installed and lagging is inserted between installed H-piles during excavation. Space

between the excavation and lagging must be suitably backfilled and drained. Lagging wall material can be selected as wood (timber), steel or concrete.

Table 2.1 Evaluation of temporary roadway protection system options

Support System	Advantages	Disadvantages	Relative Cost	Risk/Consequences	Rank
Driven Steel Sheet Piling	<ul style="list-style-type: none"> • Straightforward installation 	<ul style="list-style-type: none"> • Limited load bearing capacity in shallow soils • Obstructions affected 	Low cost of construction	<ul style="list-style-type: none"> • Installation may be difficult if obstructions are encountered in the fill 	1
Soldier H-Pile and Lagging	<ul style="list-style-type: none"> • Appropriate for shallow and deep installation 	<ul style="list-style-type: none"> • May require bracing/ tieback anchors depending on depth of excavation into overburden 	More expensive	<ul style="list-style-type: none"> • Piles could be long • Potential for loss of soil through laggings 	2

For design of the timber lagging, earth pressures can be reduced by 25 percent to account for soil arching effects. This is provided that the center-to-center spacing of the soldier piles does not exceed 2.5 m. Soldier piles should extend a minimum depth of 3.0 m below the planned excavation depth. The actual depth of embedment should be determined by balancing moments about the pile tip. Excavation can proceed following installation of the soldier piles. The unshored height of the excavation should not exceed 1.2 m at any given time. No excavation height should remain unshored for more than 24 hours. Any loose zones from behind the shoring should be prevented during installation of the protection system. If required, backfill Granular A should be placed and compacted behind the shoring wall.

For the relatively shallow depth of excavation anticipated, cantilevered systems may be adequate. However depending on the actual excavation depth and shoring system used, additional anchorage or tiebacks may be required. This must be confirmed by the shoring designer. Conventional practice is to incorporate either buried deadman anchors, grouted soil anchors or rakers. Deadman anchors can be designed based on the earth pressure coefficients and soil parameters provided in Section 2.4, following. For this project, either continuous or individual concrete block anchors would likely be appropriate. The anchor resistance is provided by a combination of the dead weight and passive resistance. For the full passive resistance to be realized with no load transfer to the wall, the anchor needs to be fully beyond the active wedge acting on the wall. Pressure grouted soil anchors can be designed in a preliminary fashion in accordance with Section 26 of the CFEM (2006). Based on the generally loose to dense sandy soils at this site, the estimated factored (0.4) ULS resistance of grouted anchors would be approximately 40 kN/m length. Detailed design should be completed following the conception of the wall and when the associated loads have been established. Normally, such anchors are supplied and installed/tested by specialist vendors/contractors.

As can be seen in the table, the steel sheet piling is ranked as more practical for this project considering the presence of loose to dense soil material. Design and construction specification for the chosen roadway protection system should be prepared in accordance with OPSS 539 by the Contractor. Pilling should be in accordance with OPSS 903. Cantilevered walls should be designed for the earth pressures shown in Section 2.4 and earth pressure diagram shown in CFEM Figure 26.3. Besides design and construction of the temporary protection system, the Contractor is also responsible for its materials, maintenance, monitoring and removal. According to OPSS 539, the protection system shall be removed from the right-of-way, unless it is specified in the Contract Documents that the protection system may be left in place. Where the piles are left in place, the top shall be removed at least 1.2 m below the finished grade level.

2.4 Lateral Pressure

The roadway protection system should be properly designed so that the lateral movement of any portion of the protection system will not exceed the established criterion for the structural performance level. In this case, Performance Level 2 would be required (OPSS 539). The shoring system should be designed by a Professional Engineer, experienced in this type of work and employed by the contractor.

The unfactored triangular lateral earth pressure distribution can be calculated as follow:

$$P = K (\gamma d + q)$$

where P = lateral earth pressure (kPa) acting at depth, d

K = earth pressure coefficient

γ = unit weight (kN/m³)

d = depth to point of interest (m)

q = surcharge near wall (kPa)

For a braced excavation in granular fill and native cohesionless soils, the unfactored rectangular earth pressure distribution can be calculated as described in Section 26.10 in CFEM (2006),

$$P_a = K_a (0.65\gamma H + q)$$

where K_a = active earth pressure coefficient

γ = unit weight (kN/m³)

H = the total depth of the excavation (m)

q = surcharge near wall (kPa)

For design purposes, the following properties given in Table 2.2 can be assumed after installation of roadway protection.

Table 2.2 Soil parameters and lateral earth pressure coefficient information required for shoring design

Abutment	Elevation (m)	Materials	Unit Weight (kN/m ³)	Unfactored Internal Angle of Friction (°)	GWL (m)	Coefficient of Lateral Earth Pressure		
						K _a	K _p	K _o
West	287.0–281.7	Sand Fill	21	32	-	0.31	3.25	0.47
	281.7-277.2	Sand	20	33		0.29	3.39	0.46
East	286.9-281.7	Sand Fill	21	32	277.3	0.31	3.25	0.47
	281.7-277.1	Sand	20	33		0.29	3.39	0.46

K_a = active earth pressure coefficient

K_o = coefficient of earth pressure at rest

K_p = passive earth pressure coefficient

2.5 Monitoring

A detailed monitoring system must be implemented by the Contractor in order to guarantee the serviceability of the half of the structure which is carrying traffic and any affected structures and utilities (OPSS 539). Monitoring of roadway protection shoring and ground movement should be done by a registered Ontario land surveyor or site engineer. If the movement of protection system approaches the allowable limit, the engineer must notify the contract administrator immediately and suitable measures should be taken to ensure stability of the protection system and ensure movement does not exceed the Performance Level 2. For Performance Level 2 of the protection systems, the maximum allowable horizontal displacement is 25 mm or maximum angular distortion is 1 to 200.

The detailed program should be developed by the bridge engineer to ensure that the magnitudes of movements are less than tolerable limits. This program should specify type, number, and location of lateral and vertical monitoring point and reading frequencies.

February 09, 2016

3 CLOSURE

The comments given in this report are intended only for the guidance of design engineers. The number of boreholes required to determine the localized underground conditions between boreholes affecting construction costs, techniques, sequencing, equipment, scheduling, etc. could be greater than has been carried out for design purposes. Contractors bidding on or undertaking the works should, in this light, decide on their own investigations, as well as their own interpretations of the factual borehole results, so that they may draw their own conclusions as to how the subsurface conditions may affect them.

This Foundation Investigation Report has been prepared by Mr. Nimesh Tamrakar, M.Eng, EIT., and Mrs. S. Micic, Ph.D., P. Eng. and reviewed by Mr. T.C. Kim, M.E.Sc., P.Eng. and Mr. S.E. Gonsalves, M.Eng., P.Eng. designated MTO foundation contact. The field investigation was conducted by Mr. Colin Schmidt, M.E.Sc.

We trust that these comments provide you with sufficient information to for your present requirements. Should you have any questions, please do not hesitate to contact this office

Yours truly,

exp Services Inc.

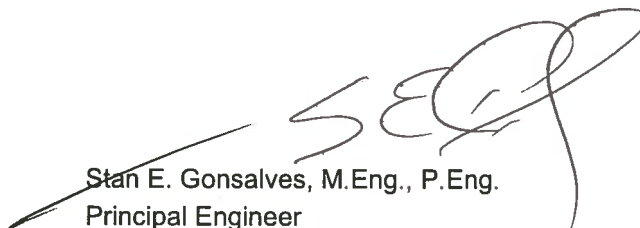


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4 LIMITATIONS AND USE OF REPORT

BASIS OF REPORT

This report ("Report") is based on site conditions known or inferred by the geotechnical investigation undertaken as of the date of the Report. Should changes occur which potentially impact the geotechnical condition of the site, or if construction is implemented more than one year following the date of the Report, the recommendations of exp may require re-evaluation.

The Report is provided solely for the guidance of design engineers and on the assumption that the design will be in accordance with applicable codes and standards. Any changes in the design features which potentially impact the geotechnical analyses or issues concerning the geotechnical aspects of applicable codes and standards will necessitate a review of the design by exp. Additional field work and reporting may also be required.

Where applicable, recommended field services are the minimum necessary to ascertain that construction is being carried out in general conformity with building code guidelines, generally accepted practices and exp's recommendations. Any reduction in the level of services recommended will result in exp providing qualified opinions regarding the adequacy of the work. exp can assist design professionals or contractors retained by the Client to review applicable plans, drawings, and specifications as they relate to the Report or to conduct field reviews during construction.

Contractors contemplating work on the site are responsible for conducting an independent investigation and interpretation of the borehole results contained in the Report. The number of boreholes necessary to determine the localized underground conditions as they impact construction costs, techniques, sequencing, equipment and scheduling may be greater than those carried out for the purpose of the Report.

Classification and identification of soils, rocks, geological units, contaminant materials, building envelopment assessments, and engineering estimates are based on investigations performed in accordance with the standard of care set out below and require the exercise of judgment. As a result, even comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations or building envelope descriptions involve an inherent risk that some conditions will not be detected. All documents or records summarizing investigations are based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated. Some conditions are subject to change over time. The Report presents the conditions at the sampled points at the time of sampling. Where special concerns exist, or the Client has special considerations or requirements, these should be disclosed to exp to allow for additional or special investigations to be undertaken not otherwise within the scope of investigation conducted for the purpose of the Report.

RELIANCE ON INFORMATION PROVIDED

The evaluation and conclusions contained in the Report are based on conditions in evidence at the time of site inspections and information provided to exp by the Client and others. The Report has

been prepared for the specific site, development, building, design or building assessment objectives and purpose as communicated by the Client. exp has relied in good faith upon such representations, information and instructions and accepts no responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of any misstatements, omissions, misrepresentation or fraudulent acts of persons providing information. Unless specifically stated otherwise, the applicability and reliability of the findings, recommendations, suggestions or opinions expressed in the Report are only valid to the extent that there has been no material alteration to or variation from any of the information provided to exp.

STANDARD OF CARE

The Report has been prepared in a manner consistent with the degree of care and skill exercised by engineering consultants currently practicing under similar circumstances and locale. No other warranty, expressed or implied, is made. Unless specifically stated otherwise, the Report does not contain environmental consulting advice.

COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment form part of the Report. This material includes, but is not limited to, the terms of reference given to exp by its client ("Client"), communications between exp and the Client, other reports, proposals or documents prepared by exp for the Client in connection with the site described in the Report. In order to properly understand the suggestions, recommendations and opinions expressed in the Report, reference must be made to the Report in its entirety. exp is not responsible for use by any party of portions of the Report.

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REPORT FORMAT

Where exp has submitted both electronic file and a hard copy of the Report, or any document forming part of the Report, only the signed and sealed hard copy shall be the original documents for record and working purposes. In the event of a dispute or discrepancy, the hard copy shall govern. Electronic files transmitted by exp have utilize specific software and hardware systems. exp makes no representation about the compatibility of these files with the Client's current or future software and hardware systems. Regardless of format, the documents described herein are exp's instruments of professional service and shall not be altered without the written consent of exp.

Appendix A Photographs



Photograph 1: East Abutment Looking West



Photograph 2: West Abutment Looking West

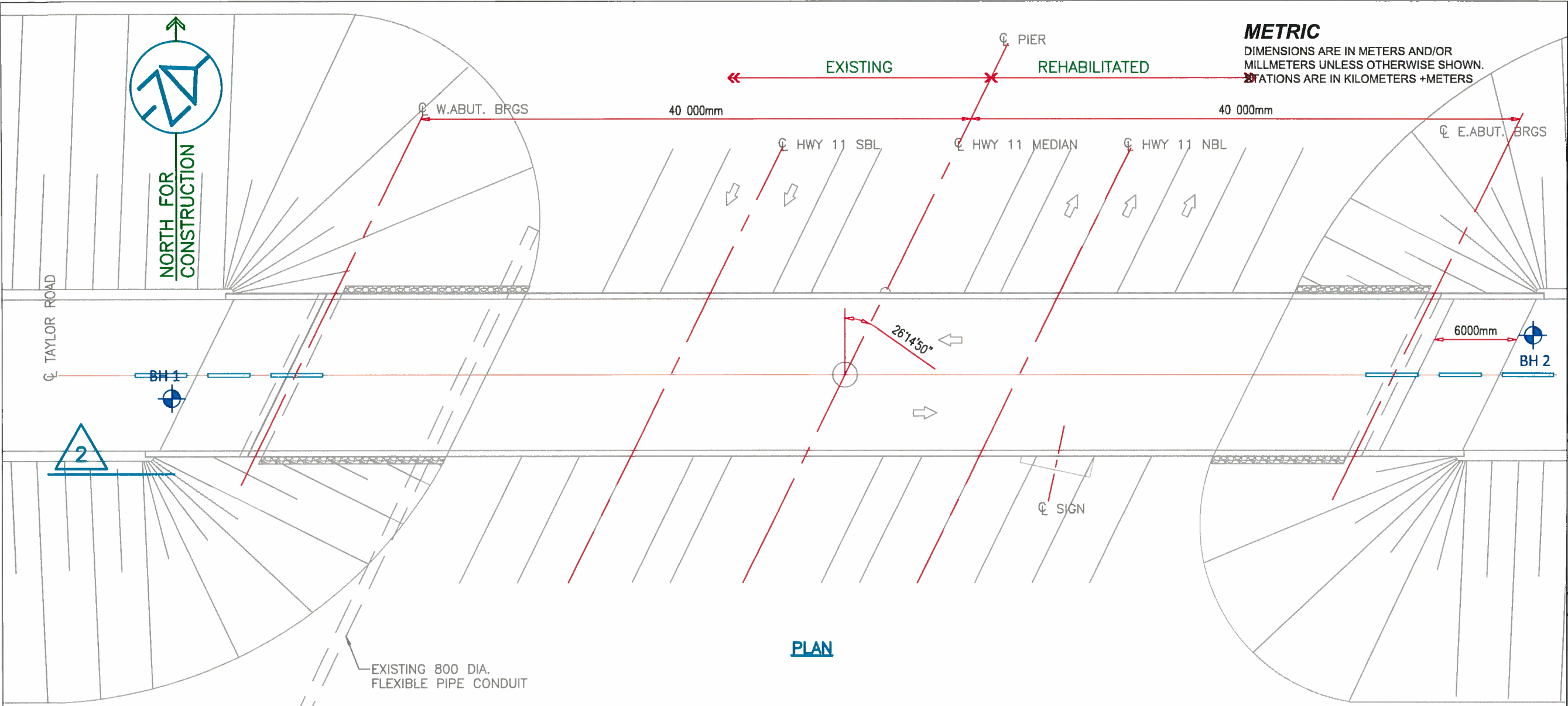


Photograph 3: East Abutment Looking South

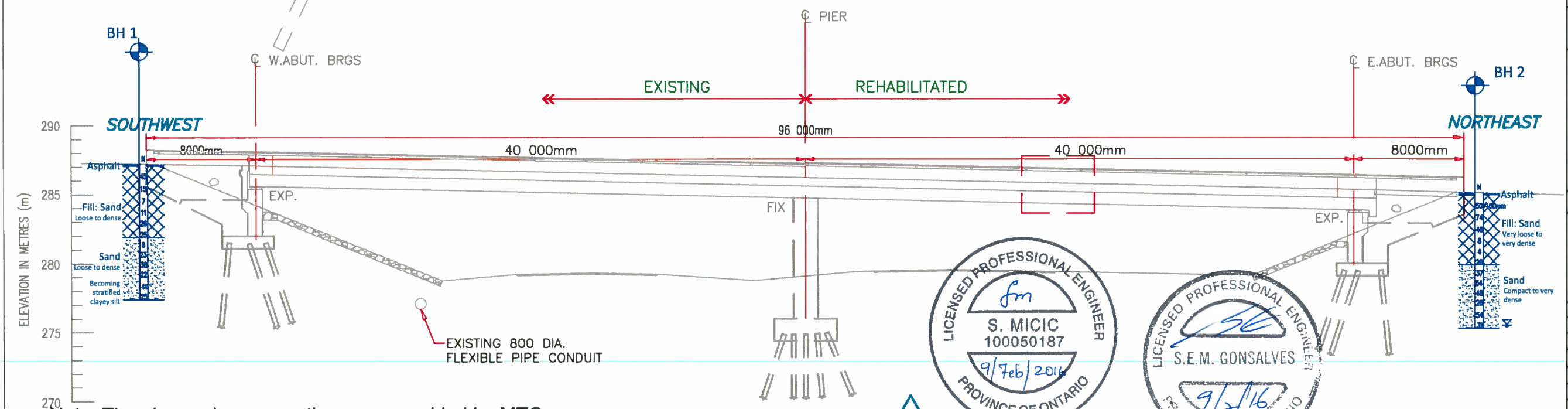


Photograph 4: West Abutment Looking North

Appendix B Drawings



PLAN



CROSS SECTION

2

METRIC
DIMENSIONS ARE IN METERS AND/OR
MILLIMETERS UNLESS OTHERWISE SHOWN.
STATIONS ARE IN KILOMETERS + METERS

DIST. No. 52
AGREEMENT. No. 5013-E-0008
WP. No. 5294-11-00

ROADWAY PROTECTION SYSTEMS, HWY 11
TAYLOR ROAD UNDERPASS
(TOWN OF BRACEBRIDGE, HWY 11/TAYLOR ROAD INTERSECTION)
BOREHOLE LOCATIONS & CROSS SECTION

SHEET 1

exp

exp Services Inc.

KEY PLAN

LEGEND

- Location of Drilled Boreholes
- Standard Penetration Test (Blows/0.3 m)
- Groundwater level measured in the open hole

SOIL STRATA SYMBOLS

- FILL
- ASPHALT
- SAND

BH No.	APPROX. ELEV. (m)	MTM CO-ORDINATES	
		NORTHING	EASTING
BH 1	287.000	4990301	321366
BH 2	286.850	4990376	321410

NOTE

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The complete foundation investigation and design report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in the report and related documents are specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen. Cond.

DATE	BY	DESCRIPTION
2016.01.15	SM	SUBMISSION FOR MTO REVIEW
DATE	BY	DESCRIPTION
GEOCRES NO. 31E-359		SITE NO. 42-0182
PROJECT NO. ADM-00028245-N0		
SUBM'D SM	CHECKED SM	DATE 2016.01.15
DRAWN JH	CHECKED SG	APPROVED DWG. 01

Note: The plan and cross section were provided by MTO.

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Appendix C – Record of Boreholes

Explanation of Terms Used on Borehole Records

SOIL DESCRIPTION

Terminology describing common soil genesis:

Topsoil: mixture of soil and humus capable of supporting good vegetative growth.

Peat: fibrous fragments of visible and invisible decayed organic matter.

Fill: where fill is designated on the borehole log it is defined as indicated by the sample recovered during the boring process. The reader is cautioned that fills are heterogeneous in nature and variable in density or degree of compaction. The borehole description may therefore not be applicable as a general description of site fill materials. All fills should be expected to contain obstruction such as wood, large concrete pieces or subsurface basements, floors, tanks, etc.; none of these may have been encountered in the boreholes. Since boreholes cannot accurately define the contents of the fill, test pits are recommended to provide supplementary information. Despite the use of test pits, the heterogeneous nature of fill will leave some ambiguity as to the exact composition of the fill. Most fills contain pockets, seams, or layers of organically contaminated soil. This organic material can result in the generation of methane gas and/or significant ongoing and future settlements. Fill at this site may have been monitored for the presence of methane gas and, if so, the results are given on the borehole logs. The monitoring process does not indicate the volume of gas that can be potentially generated nor does it pinpoint the source of the gas. These readings are to advise of the presence of gas only, and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic/hazardous waste that renders it unacceptable for deposition in any but designated land fill sites; unless specifically stated the fill on this site has not been tested for contaminants that may be considered toxic or hazardous. This testing and a potential hazard study can be undertaken if requested. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common and are generally not detected in a conventional geotechnical site investigation.

Till: the term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process the till must be considered heterogeneous in composition and as such may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (60 to 200 mm) or boulders (over 200 mm). Contractors may therefore encounter cobbles and boulders during excavation, even if they are not indicated by the borings. It should be appreciated that normal sampling equipment cannot differentiate the size or type of any obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited zone; caution is therefore essential when dealing with sensitive excavations or dewatering programs in till materials.

Terminology describing soil structure:

Desiccated: having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.

Stratified: alternating layers of varying material or color with the layers greater than 6 mm thick.

Laminated: alternating layers of varying material or color with the layers less than 6 mm thick.

Fissured: material breaks along plane of fracture.

Varved: composed of regular alternating layers of silt and clay.

Slickensided: fracture planes appear polished or glossy, sometimes striated.

Blocky: cohesive soil that can be broken down into small angular lumps which resist further breakdown.

Lensed: inclusion of small pockets of different soil, such as small lenses of sand scattered through a mass of clay; not thickness.

Seam: a thin, confined layer of soil having different particle size, texture, or color from materials above and below.

Homogeneous: same color and appearance throughout.

Well Graded: having wide range in grain sized and substantial amounts of all predominantly on grain size.

Uniformly Graded: predominantly on grain size.

All soil sample descriptions included in this report follow generally the ASTM D2487-11 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System) with some modification to reflect current MTO practices. The system divides soils into three major categories: (1) coarse grained, (2) fine-grained, and (3) highly organic. The soil is then subdivided based on either gradation or plasticity characteristics. The system provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification. The classification excludes particles larger than 76 mm. Please note that, with the exception of those samples where a grain size analysis has been made, all samples are classified visually in accordance with ASTM D2488-09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). Visual classification is not sufficiently accurate to provide exact grain sizing or precise differentiation between size classification systems. Others may use different classification systems; one such system is the ISSMFE Soil Classification.

ISSMFE SOIL CLASSIFICATION											
CLAY	SILT			SAND			GRAVEL			COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE		
<div><div>0.002</div><div>0.006</div><div>0.02</div><div>0.06</div><div>0.2</div><div>0.6</div><div>2.0</div><div>6.0</div><div>20</div><div>60</div><div>200</div></div>											
EQUIVALENT GRAIN DIAMETER IN MILLIMETRES											
CLAY (PLASTIC) TO				FINE		MEDIUM		CRS.		FINE COARSE	
SILT (NONPLASTIC)				SAND				GRAVEL			
UNIFIED SOIL CLASSIFICATION											

Terminology describing materials outside the USCS, (e.g. particles larger than 76 mm, visible organic matter, construction debris) is based upon the proportion of these materials present and as described below in accordance with Note 16 in ASTM D2488-09a:

Table a: Percent or Proportion of Soil, Pp

	Criteria
Trace	Particles are present but estimated to be less than 5%
Few	$5 \leq Pp \leq 10\%$
Little	$15 \leq Pp \leq 25\%$
Some	$30 \leq Pp \leq 45\%$
Mostly	$50 \leq Pp \leq 100\%$

The standard terminology to describe cohesionless soils includes the compactness as determined by the Standard Penetration Test 'N' value:

Table b: Apparent Density of Cohesionless Soil

	'N' Value (blows/0.3 m)
Very Loose	$N < 5$
Loose	$5 \leq N < 10$
Compact	$10 \leq N < 30$
Dense	$30 \leq N < 50$
Very Dense	$50 \leq N$

The standard terminology to describe cohesive soils includes consistency, which is based on undrained shear strength as measured by insitu vane tests, penetrometer tests, unconfined compression tests or similar field and laboratory analysis, Standard Penetration Test 'N' values can also be used to provide an approximate indication of the consistency and shear strength of fine grained, cohesive soils:

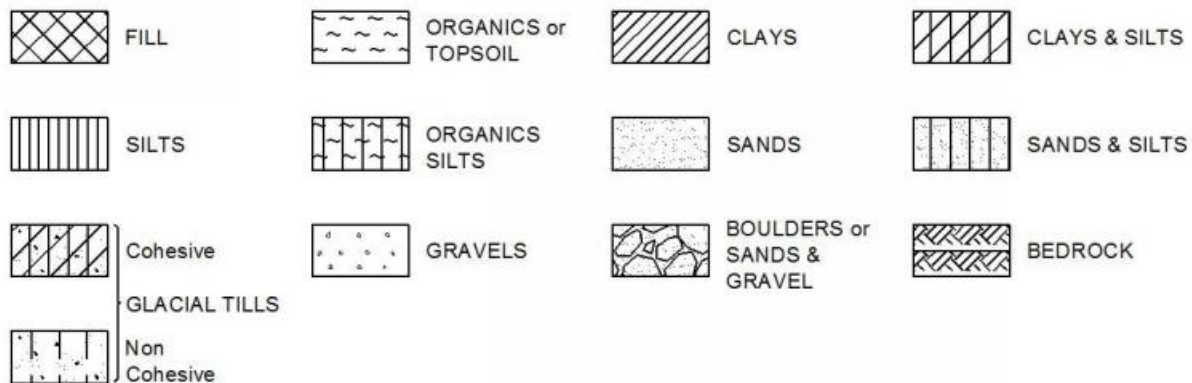
Table c: Consistency of Cohesive Soil

Consistency	Vane Shear Measurement (kPa)	'N' Value
Very Soft	<12.5	<2
Soft	12.5-25	2-4
Firm	25-50	4-8
Stiff	50-100	8-15
Very Stiff	100-200	15-30
Hard	>200	>30

Note: 'N' Value - The Standard Penetration Test records the number of blows of a 140 pound (64kg) hammer falling 30 inches (760mm), required to drive a 2 inch (50.8mm) O.D. split spoon sampler 1 foot (305mm). For split spoon samples where full penetration is not achieved, the number of blows is reported over the sampler penetration in meters (e.g. 50/0.15).

STRATA PLOT

Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols:



WATER LEVEL MEASUREMENT



ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

SS	Split spoon sample (obtained from the Standard Penetration Test)
WS	Wash sample
BS	Bulk sample
TW	Thin wall sample or Shelby tube
PS	Piston sample
AS	Auger sample
VT	Vane test
GS	Grab sample
HQ, NQ, etc.	Rock core samples obtained with the use of standard size diamond drilling bits

STRESS AND STRAIN

u_w	kPa	Pore water pressure
r_u	1	Pore pressure ratio
σ	kPa	Total normal stress
σ'	kPa	Effective normal stress
τ	kPa	Shear stress
$\sigma_1, \sigma_2, \sigma_3$	kPa	Principal stresses
ε	%	Linear strain
$\varepsilon_1, \varepsilon_2, \varepsilon_3$	%	Principal strains
E	kPa	Modulus of linear deformation
G	kPa	Modulus of shear deformation
μ	1	Coefficient of friction

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	Coefficient of volume change
c_c	1	Compression index
c_s	1	Swelling index
c_r	1	Recompression index
c_v	m^2/s	Coefficient of consolidation
H	m	Drainage path
T_v	1	Time factor
U	%	Degree of consolidation
σ'_{v0}	kPa	Effective overburden pressure
σ'_p	kPa	Preconsolidation pressure
τ_f	kPa	Shear strength
c'	kPa	Effective cohesion intercept
ϕ'	$^\circ$	Effective angle of internal friction
c_u	kPa	Apparent cohesion intercept
ϕ_u	$^\circ$	Apparent angle of internal friction
τ_R	kPa	Residual shear strength
τ_r	kPa	Remoulded shear strength
S_t	1	Sensitivity = c_u/τ_r

PHYSICAL PROPERTIES OF SOIL

P_s	kg/m^3	Density of solid particles
γ_s	kN/m^3	Unit weight of solid particles
ρ_w	kg/m^3	Density of water
γ_w	kN/m^3	Unit weight of water
ρ	kg/m^3	Density of soil
γ	kN/m^3	Unit weight of soil
ρ_d	kg/m^3	Density of dry soil
γ_d	kN/m^3	Unit weight of dry soil
ρ_{sat}	kg/m^3	Density of saturated soil
γ_{sat}	kN/m^3	Unit weight of saturated soil
ρ'	kg/m^3	Density of submerged soil
γ'	kN/m^3	Unit weight of submerged soil
e	1, %	Void ratio
n	1, %	Porosity
w	1, %	Water content
S_r	%	Degree of saturation
W_L	%	Liquid limit
W_P	%	Plastic limit
W_s	%	Shrinkage limit
I_p	%	Plasticity index = $(W_L - W_P)$
I_L	%	Liquidity index = $(W - W_P)/I_p$
I_C	%	Consistency index = $(W_L - W)/I_p$
e_{max}	1, %	Void ratio in loosest state
e_{min}	1, %	Void ratio in densest state
I_D	1	Density index = $(e_{max} - e)/(e_{max} - e_{min})$
D	mm	Grain diameter
D_n	mm	N percent - diameter
C_u	1	Uniformity coefficient
h	m	Hydraulic head or potential
q	m^3/s	Rate of discharge
v	m/s	Discharge velocity
i	1	Hydraulic gradient
k	m/s	Hydraulic conductivity
j	kN/m^3	Seepage force

Brampton, Ontario

RECORD OF BOREHOLE No BH1

1 OF 1

METRIC

W. P. GWP 5294-11-00 LOCATION Taylor Rd Underpass, (Site No. 42-0182), ON, (N 4990301 E 321366) ORIGINATED BY CS
 DIST Town of Bracebridge BOREHOLE TYPE CME-55, Hollow Stem Augers COMPILED BY NT
 DATUM Geodetic DATE 2015/12/17 - 2015/12/17 CHECKED BY SM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)									
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH: Cu, KPa									WATER CONTENT (%)			GR	SA	SI	CL			
								○ UNCONFINED + FIELD VANE									○							3	88	(9)
								× QUICK TRIAXIAL LAB VANE																		
287.0	Ground Surface						20	40	60	80	100															
286.9	ASPHALT: 150mm						20	40	60	80	100															
0.2	FILL: SAND trace to some gravel, brown to greyish brown, loose to dense, moist																									
			1	SS	45		286						○													
			2	SS	15		285						○					3	88 (9)							
			3	SS	7		284						○													
			4	SS	11		283						○													
			5	SS	26		282						○					3	92 (5)							
	-becoming trace coarse sand @ 4.7 m		6	SS	25		281						○													
281.7			7	SS	6		280						○					1	69 19 11							
5.3	SAND fine to medium sand, trace to few gravel, trace silt, trace clay, brown to greyish brown, loose to dense, moist to wet -becoming clayey silt @ 5.5 m, greyish brown, very moist		8	SS	23		279						○													
			9	SS	38		278						○													
			10	SS	22								○													
			11	SS	41								○													
	- becoming stratified clayey silt		12	SS	25									○				0	73 (27)							
277.2	END OF BOREHOLE																									
9.8	NOTES: 1. This drawing is to be read with the subject report and project numbers as presented above. 2. Interpretation assistance by exp is required before used by others. 3. Groundwater level dry upon completion of borehole. Borehole caved @ 8.1 m upon removal of auger																									

OPG_EXP RECORD OF BOREHOLE TAYLOR RD UNDERPASS.GPJ ONTARIO MOT.GDT 1/20/16

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Brampton, Ontario

RECORD OF BOREHOLE No BH2

1 OF 1

METRIC

W. P. GWP 5294-11-00 LOCATION Taylor Rd Underpass, (Site No. 42-0182), ON, (N 4990376 E 321410) ORIGINATED BY CS
 DIST Town of Bracebridge BOREHOLE TYPE CME-55, Hollow Stem Augers COMPILED BY NT
 DATUM Geodetic DATE 2015/12/18 - 2015/12/18 CHECKED BY SM

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		20	40	60	80	100	W _p	W	W _L		
286.9	Ground Surface															
286.8	ASPHALT: 150mm															
0.2	FILL: SAND trace to some gravel, brown to greyish brown, very loose to very dense, moist															
			1	SS	50/ 100mm							o				
			2	SS	74							o				
			3	SS	46							o				
			4	SS	8							o				3 92 (5)
			5	SS	4							o				
			6	SS	28							o				
281.7																
5.2	SAND trace to little gravel, trace silt, trace clay, trace rootlets, brown to greyish brown, compact to very dense, moist to wet -becoming minor oxidation		7	SS	37							o				
			8	SS	54							o				13 84 (3)
	- becoming trace coarse gravel		9	SS	48							o				
	- becoming trace rootlets		10	SS	26							o				10 82 (8)
			11	SS	54							o				
			12	SS	31								o			
277.1																
9.8	END OF BOREHOLE															
	NOTES: 1. This drawing is to be read with the subject report and project numbers as presented above. 2. Interpretation assistance by exp is required before used by others. 3. Groundwater level at 9.6 m depth upon completion of borehole. Borehole caved @ 7.7 m upon removal of auger															

OPG_EXP RECORD OF BOREHOLE TAYLOR RD UNDERPASS.GPJ ONTARIO MOT.GDT 1/20/16

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Appendix D – Results of Laboratory Tests

