



April 2011

FOUNDATION INVESTIGATION AND DESIGN REPORT

**CANTILEVERED SIGN SUPPORT STRUCTURE AT HWY
401/ISLINGTON AVENUE INTERCHANGE
TORONTO, ONTARIO**

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REPORT

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Distribution:

3 Copies - Lowe's Companies Canada, North York, ON
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PART A

FOUNDATION INVESTIGATION REPORT CANTILEVERED SIGN SUPPORT STRUCTURE AT HIGHWAY 401/ISLINGTON AVE. INTERCHANGE TORONTO, ONTARIO



1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Lowe's Companies Canada, ULC (Lowe's) to provide foundation engineering services associated with the detail design of a new cantilevered sign support structure as part of the proposed re-alignment of the Highway 401/Islington Avenue S-E Ramp in the City of Toronto.

Although no specific terms of references were prepared by the Ministry of Transportation (MTO), this report addresses the foundation investigation for the single proposed overhead sign support in general accordance with Ministry of Transportation (MTO) foundation standards.

This report addresses only the geotechnical (physical) aspects of the subsurface conditions at this site. The geo-environmental (chemical) aspects, including consequences of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources, are outside the terms of reference for this report.

The factual data, interpretations and recommendations contained in this report pertain to a specific project as described in the report and are not applicable to any other project or site location. If the project is modified in concept, location or elevation, or if the project is not initiated within twelve months of the date of the report, Golder should be given an opportunity to confirm that the recommendations are still valid.

This report should be read in conjunction with the "Important Information and Limitations of This Report", following the text of this report. The reader's attention is specifically drawn to this information, as it is essential for the proper use and interpretation of this report.

2.0 SITE AND PROJECT DESCRIPTION

The proposed sign support structure is located at the southeast corner of the Highway 401 and Islington Avenue interchange, immediately west of the current south-east ramp (refer to Key Plan on Drawing 1). The ground surface in the vicinity of the proposed sign structure is generally flat and is currently a grass covered boulevard area.

3.0 INVESTIGATION PROCEDURES

A subsurface investigation was carried out at the proposed sign support structure location on March 8, 2011, at which time one borehole (Borehole F1) was advanced using a track mounted drill rig, supplied and operated by Profile Drilling Ltd. The borehole location is shown on Drawing 1.

The borehole was advanced to depth of 8.1 m below ground surface using hollow stem augers. Soil samples were obtained at 0.75 m and 1.5 m intervals of depth, using 50 mm outside diameter split-spoon samplers driven by an automatic hammer in accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586).

The open borehole was observed to be dry throughout the drilling operations. Upon completion, the borehole was backfilled to the surface with bentonite pellets in accordance with Ontario Regulation (O. Reg.) 903 as amended by O. Reg 372/07 of the Ontario Water Resources Act.



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The field work was supervised on a full-time basis by a member of Golder's technical staff who located the borehole in the field relative to on-site features, obtained service clearances, directed the drilling, sampling, and in situ testing operations, and logged the boreholes. The soil samples were identified in the field, placed in labelled containers and transported to Golder's laboratory in Whitby for further examination and testing. Index and classification tests consisting of water contents, Atterberg limits and grain size distributions were carried out on selected soil samples.

The approximate location (referenced to on-site features) of the as-drilled borehole location was plotted on the plan and profile drawings provided to Golder. From the drawings, the approximate borehole location (referenced to MTM NAD83 coordinates) and ground surface elevation (referenced to geodetic datum) was obtained (summarized below) and is shown on Drawing 1.

Borehole Number	MTM NAD83 Northing (m)	MTM NAD83 Easting (m)	Ground Surface Elevation (m)
F1	4,840,850.5	300,665.5	157.2

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

The site is located within the Peel Plain physiographic region, as delineated in *The Physiography of Southern Ontario*¹. A surficial till sheet, which generally follows the surface topography, is present throughout much of this area. The till is typically comprised of clayey silt to silty clay, with occasional sand to silt zones; it is mapped in this area as the Halton Till. The results of the investigation are generally consistent with the physiographic information.

4.2 Site Stratigraphy

One borehole (F1) was advanced at this site at the location shown on Drawing 1. The detailed subsurface soil and groundwater conditions encountered in the borehole and the results of in situ and laboratory testing are summarized on the Record of Borehole sheet. The stratigraphic boundaries shown on the borehole record are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary beyond the borehole location.

In summary, the subsoil conditions encountered in the borehole consist of granular fill over a layer of clayey silt fill, which is underlain by a deposit of clayey silt till. A more detailed description of the subsurface conditions encountered in the borehole is provided in the following sections.

4.2.1 Topsoil

Topsoil with an approximate thickness of 0.2 m was encountered at the ground surface in the borehole.

¹ Chapman, L.J. and D.F. Putnam. *The Physiography of Southern Ontario*, Ontario Geological Survey Special Volume 2, Third Edition, 1984. Accompanied by Map P.2715, Scale 1:600,000.



4.2.2 Sand and Gravel (Fill)

Sand and gravel fill was encountered below the topsoil and extends to an approximate depth of 0.8 m below existing ground surface (bgs).

The measured water content of a sand and gravel fill sample was about 4 percent.

4.2.3 Clayey Silt (Fill)

Clayey silt with sand fill was encountered in the borehole underlying the sand and gravel fill and extends to a depth of 3.7 m bgs. The measured Standard Penetration Test (SPT) 'N' values within the clayey silt fill with sand ranged from 9 blows to 18 blows per 0.3 m of penetration, suggesting a stiff to very stiff consistency.

The measured water contents of the clayey silt samples range from 10 percent to 19 percent. The results of one grain size distribution test on a sample of the clayey silt with sand fill is shown on Figure 1.

4.2.4 Clayey Silt Till

A deposit of clayey silt with sand till was encountered below the clayey silt fill in the borehole and extended to the termination depth of 8.1 m bgs. The measured thickness of the clayey silt with sand till deposit was 4.4 m upon termination. The deposit transitioned from a grey colour to a brown colour at a depth of about 6 m bgs. The measured SPT "N" values in the clayey silt with sand till from a depth of 3.6 m to 6 m were between 9 blows and 11 blows per 0.3 m of penetration, suggesting the till has a stiff consistency in this upper zone. The measured SPT "N" values in the clayey silt with sand till from a depth 6 m to 8.1 m were between 23 blows and 39 blows per 0.3 m of penetration, indicating that the till has a very stiff to hard consistency in this lower zone.

The water contents of the clayey silt with sand till range from 10 percent to 20 percent. The results of two grain size distribution tests completed on two selected samples of this till deposit are shown on Figure 2. Two Atterberg limits tests carried out on two samples of the till measured plastic limits of 14 percent and 16 percent, liquid limits of 21 percent and 27 percent and corresponding plasticity indices of 7 percent and 11 percent. The results of the Atterberg limits testing are shown on the Record of Borehole sheet and the plasticity chart shown on Figure 3, and confirm that this material is a clayey silt of low plasticity.

4.2.5 Groundwater Conditions

The borehole was dry upon completion of drilling on March 8, 2011. However, the groundwater level is expected to fluctuate seasonally and is expected to rise during periods of high precipitation and during snow melt.



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5.0 CLOSURE

This Foundation Investigation Report was prepared by Mr. Mehdi Mostakhdemi and reviewed by Mr. Kevin Bentley, P.Eng., an Associate and geotechnical engineer with Golder. Mr. Ty Garde, P.Eng, a Principal and Designated MTO Contact for Foundations, conducted an independent quality review of the report.

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PART B

FOUNDATION DESIGN REPORT CANTILEVERED SIGN SUPPORT STRUCTURE AT HIGHWAY 401/ISLINGTON AVE. INTERCHANGE TORONTO, ONTARIO



6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides foundation design recommendations for the single cantilevered sign support structure at the proposed new Highway 401/Islington Avenue S-E Ramp location in Toronto, Ontario. These recommendations are based on interpretation of the factual data obtained during the subsurface investigation.

The interpretation and recommendations contained in this report are intended for use by the design engineer. Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project, and for which special provisions may be required in the contract documents. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, construction methods and scheduling.

6.2 Caisson Foundations for Cantilevered Overhead Signs

Caisson foundations for cantilevered sign supports should be designed in accordance with the requirements in MTO's Sign Support Manual (MTO, 2007). The Sign Support Manual includes standard caisson foundation design (Section 3 and Standard Drawings SS 118-3, SS 118-4 and SS 118-5), in which the caisson is extended 5 m to 6.5 m below the design frost depth (i.e. 1.2 m as per OPSD 3090.101 Foundation Frost Depths for Southern Ontario) resulting in a total length of 6.2 to 7.7 m below grade depending on the sign class and corresponding caisson diameter.

The standard sign foundation designs presented in the MTO's Sign Support Manual have been developed based on the minimum soil conditions given below.

- **Case 1 (Cohesionless Soils):** Sand with a friction angle of 28 degrees surrounding the upper two-thirds of the caisson foundation below the frost depth, and sand with a friction angle of 30 degrees surrounding the lower third of the portion of the caisson below the design frost depth.
- **Case 2 (Cohesive Soils):** Soft clay with an undrained shear strength of 25 kPa surrounding the upper two-thirds of the portion of the caisson foundation below the frost depth, and "soft" clay with an undrained shear strength of 50 kPa surrounding the lower third of the portion of the caisson below the design frost depth.

The standard foundation design provided in MTO's Sign Support Manual does not apply to sites where extensive poor fill materials or materials softer than those at Case 2 are present. For such conditions, a site-specific design is required. Based on the review of the borehole information, the soil conditions at the borehole location (F1) have friction angles and/or undrained shear strengths that exceed the input parameters used in the modelling of the standard caisson foundations and, therefore, the standard caisson foundation design is suitable for this site.

6.2.1 Lateral Geotechnical Resistance

The standard foundation design may be checked and optimized by the structural designer using the recommendations provided below. A site-specific caisson design may be carried out using the following equations to calculate the unfactored passive lateral earth pressure, P_p (kPa), distributed along the length of the caisson, based on the stratigraphy and geotechnical design parameters given in Table 1 following the text of this report.



$$\begin{aligned} P_p &= K_p \gamma d && \text{(above the groundwater table)} \\ P_p &= K_p \gamma d_w + K_p \gamma' (d - d_w) && \text{(below the groundwater table)} \end{aligned}$$

where

K_p	is the passive earth pressure coefficient
γ	is the bulk unit weight (kN/m^3);
γ'	is the effective unit weight below the groundwater level (kN/m^3);
d	is the depth below the ground surface (m); and
d_w	is the depth to the groundwater level (m)

In the design of the foundations, the passive resistance within the upper 1.2 m below ground surface should be neglected to account for frost action. The unfactored lateral resistance should be calculated assuming an equivalent width equal to three times the caisson diameter. A resistance factor of 0.5 should be applied to this unfactored lateral resistance to obtain the factored lateral geotechnical resistance at Ultimate Limit Status (ULS).

Where an undrained shear strength, C_u , is provided for a cohesive soil layer in Table 1, the undrained capacity of the caisson should be checked to determine whether the drained or undrained case will govern. In this case, the lateral resistance for the length of the caisson within cohesive soil should be calculated assuming an internal angle of friction, $\phi' = 0$ degrees, and an unfactored passive lateral pressure distribution varying from $2 C_u$ at the ground surface to $9 C_u$ at and below a depth equivalent to the three caisson diameters, acting over the actual width of the caisson. A resistance factor of 0.5 should be applied to this calculated lateral resistance in order to obtain the factored lateral geotechnical resistance at ULS.

6.3 Construction Considerations

6.3.1 Control of Soil and Groundwater

Interlayers and lenses of potentially water-bearing cohesionless soils may be present within the fill soils at the site. "Perched" groundwater may also be encountered at the base of cohesionless fill materials, atop the underlying, less permeable clayey silt fill or till deposit. Wet cohesionless fills or cohesive fills with significant sand content should be expected to run or flow into the caisson hole during or after drilling for the foundations. Therefore, temporary or permanent caisson liners are recommended to minimize ground loss during drilling and concrete placement.

Construction of the caisson foundation for the cantilevered sign support structure should be in accordance with OPSS 915 (Construction Specification for Sign Support Structures).



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7.0 CLOSURE

This Foundation Design Report was prepared by Mr. Mehdi Mostakhdemi, M.Sc., M.Eng., and reviewed by Mr. Kevin Bentley, P.Eng., a geotechnical engineer and Associate with Golder. Mr. Ty Garde, P.Eng., Golder's Designated MTO Contact for this project and Principal with Golder, conducted an independent quality control review of the report.

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IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

Standard of Care: Golder Associates Ltd. (Golder) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practising under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

Basis and Use of the Report: This report has been prepared for the specific site, design objective, development and purpose described to Golder by the Client. The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. Golder can not be responsible for use of this report, or portions thereof, unless Golder is requested to review and, if necessary, revise the report.

The information, recommendations and opinions expressed in this report are for the sole benefit of the Client. No other party may use or rely on this report or any portion thereof without Golder's express written consent. If the report was prepared to be included for a specific permit application process, then upon the reasonable request of the client, Golder may authorize in writing the use of this report by the regulatory agency as an Approved User for the specific and identified purpose of the applicable permit review process. Any other use of this report by others is prohibited and is without responsibility to Golder. The report, all plans, data, drawings and other documents as well as all electronic media prepared by Golder are considered its professional work product and shall remain the copyright property of Golder, who authorizes only the Client and Approved Users to make copies of the report, but only in such quantities as are reasonably necessary for the use of the report by those parties. The Client and Approved Users may not give, lend, sell, or otherwise make available the report or any portion thereof to any other party without the express written permission of Golder. The Client acknowledges that electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore the Client can not rely upon the electronic media versions of Golder's report or other work products.

The report is of a summary nature and is not intended to stand alone without reference to the instructions given to Golder by the Client, communications between Golder and the Client, and to any other reports prepared by Golder for the Client relative to the specific site described in the report. In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. Golder can not be responsible for use of portions of the report without reference to the entire report.

Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

Soil, Rock and Groundwater Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Golder does not warrant or guarantee the exactness of the descriptions.



IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report. The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder's report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder's report.

During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder's report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in Golder's report. Adequate field review, observation and testing during construction are necessary for Golder to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Golder's responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Golder be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Golder be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Golder takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.



REFERENCES

Chapman, L.J., and Putnam, D.F. 1984. *The Physiography of Southern Ontario*, 3rd Edition. Ontario Geological Survey, Special Volume 2. Ontario Ministry of Natural Resources.

Ministry of Transportation, Ontario, 2007. *Sign Support Manual*, Policy, Planning & Standards Division, Engineering Standards Branch, Bridge Office.

Standards:

ASTM International:

ASTM D1586-08a Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils.

Ontario Provincial Standard Specification (OPSS)

OPSS 915 Construction Specification for Sign Support Structures, November 2005.

Ontario Provincial Standard Drawings (OPSD)

OPSD 3090-101 Foundation Frost Depths for Southern Ontario



DRAFT FOUNDATION REPORT FOR CANTILEVERED SIGN SUPPORT AT HWY401/ISLINGTON AVENUE INTERCHANGE

TABLE 1
GEOTECHNICAL DESIGN PARAMETERS FOR CANTILEVERED SIGN SUPPORT STRUCTURE FOUNDATION
HIGHWAY 401/ISLINGTON AVENUE INTERCHANGE

Borehole No.	Borehole Location (MTM NAD 83 coordinates)	Stratum	Depth ¹ (m)	Elevation ¹ (m)	Groundwater Elevation ²	Design Parameters ^{3,4}				
						c_u	ϕ'	γ	γ'	K_p
F1	N 4,840,850.5 E 300,665.9	Sand and gravel fill	0.2 – 0.8	157.0 – 156.4	Borehole dry upon completion of drilling	-	28	19	9	2.8
		Stiff to very stiff clayey silt fill	0.8 – 3.7	156.4 – 153.5		50	30	19	9	3.0
		Stiff clayey silt till	3.7 – 5.6	153.5 – 151.6		60	32	20	10	3.2
		Very stiff to hard clayey silt till	Below 5.6	Below 151.6		150	34	21	11	3.5

Reviewed by: K.J. Bentley

- NOTES:**
1. Depth is given at the borehole location; the ground surface elevation at the borehole location should be compared to the ground surface elevation at the actual cantilevered sign support location, and the depths and/or elevations to various soil stratum adjusted accordingly.
 2. Borehole F1 was dry upon completion of drilling. No standpipe piezometer was installed and stabilized water levels were not measured.
 3. Design parameters: c_u = undrained shear strength (kPa);
 ϕ' = effective friction angle (degrees);
 γ = bulk unit weight (kN/m³);
 γ' = effective unit weight below the groundwater level (kN/m³); and
 K_p = passive earth pressure coefficient.
 4. Although the passive resistance in the upper 1.2 m is to be neglected to account for frost action, ϕ' and K_p parameters are given in the event that the ground surface elevation varies significantly between the borehole and sign support locations.



LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DO	Drive open
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; N_d :

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

PH:	Sampler advanced by hydraulic pressure
PM:	Sampler advanced by manual pressure
WH:	Sampler advanced by static weight of hammer
WR:	Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Cohesionless Soils

Density Index	N
Relative Density	Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils Consistency

	C_u, S_u	psf
	kPa	
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.



LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
$\ln x$,	natural logarithm of x
\log_{10}	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
F	factor of safety
V	volume
W	weight

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma$
ϵ	linear strain
ϵ_v	volumetric strain
η	coefficient of viscosity
ν	poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - \mu$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
μ	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight*)
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

(a) Index Properties (continued)

w	water content
w_l	liquid limit
w_p	plastic limit
I_p	plasticity index $= (w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index $= (w - w_p) / I_p$
I_C	consistency index $= (w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index $= (e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_a	coefficient of secondary consolidation
m_v	coefficient of volume change
c_v	coefficient of consolidation
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation pressure
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

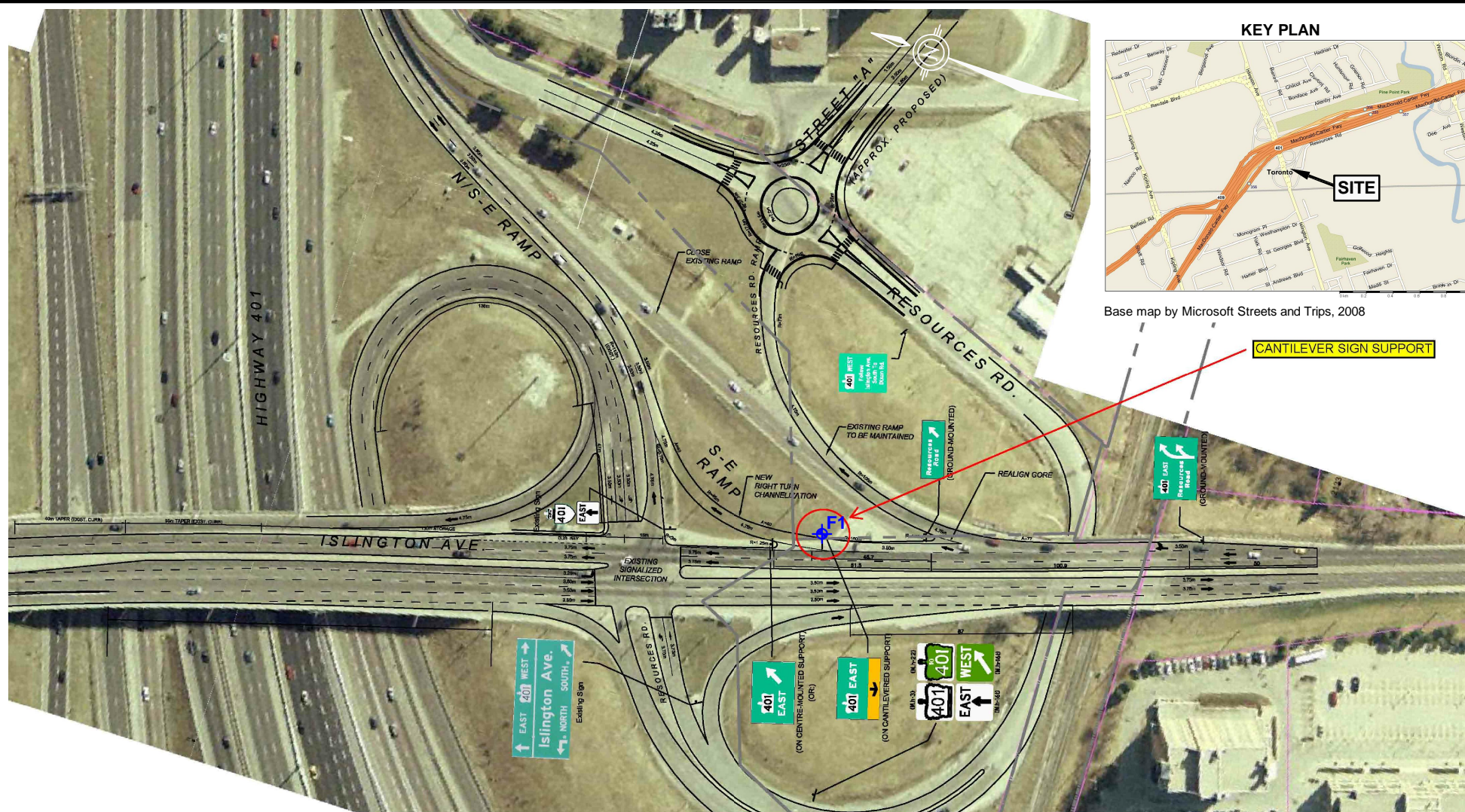
T_p, T_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction $= \tan \delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 + \sigma_3)/2$ or $(\sigma'_1 + \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 + \sigma_3)$
S_t	sensitivity

* Density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

Notes: 1 $\tau = c' + \sigma' \tan \phi'$
2 shear strength = (compressive strength)/2

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



NOT TO SCALE
ALL LOCATIONS ARE APPROXIMATE

LEGEND



BOREHOLE LOCATION IN PLAN

REFERENCE

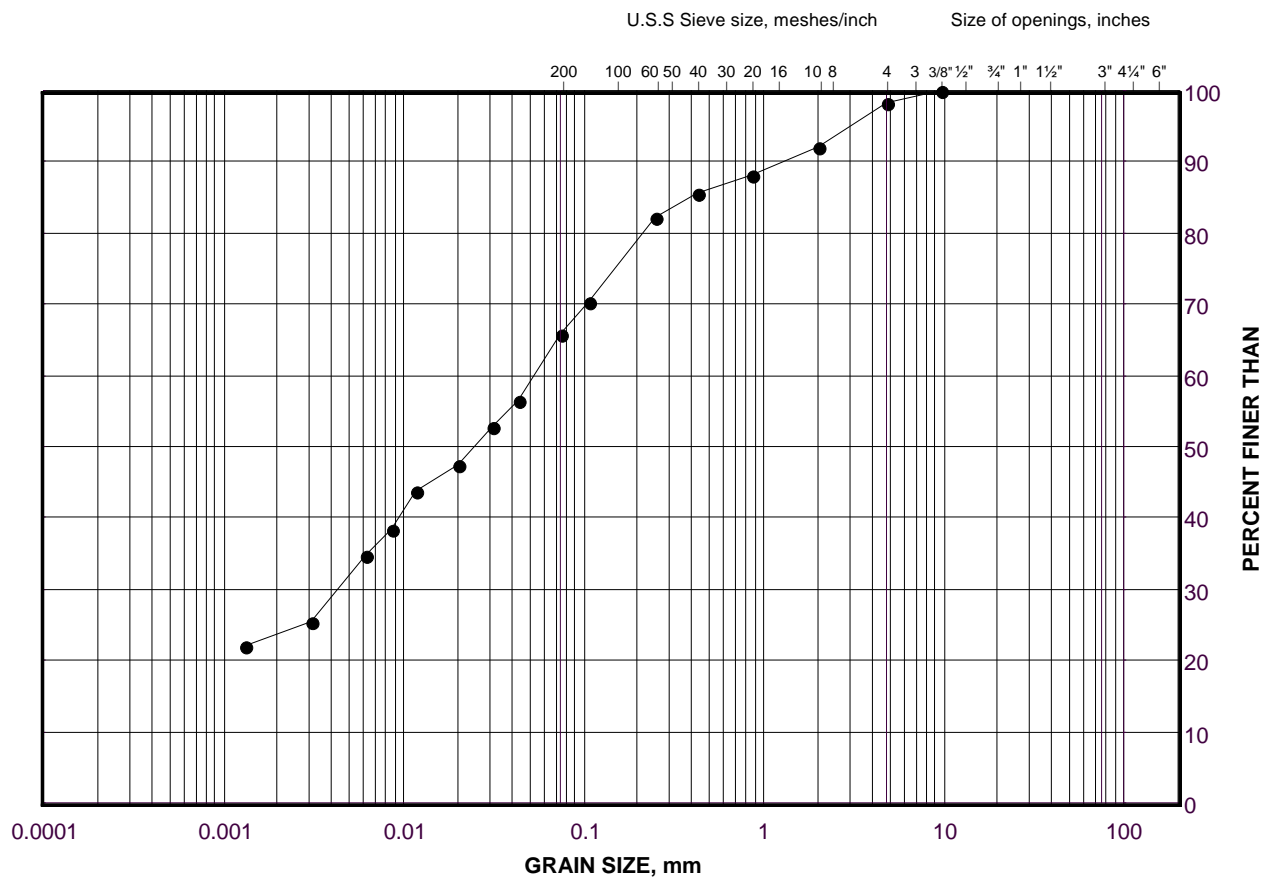
Drawing provided by Dillon Consulting, entitled "Revised Functional Design - Resources Road and Highway 401 Interchange", dated July 2010.

PROJECT	Lowe's Companies Canada Cantilever Sign at Hwy 401/Islington Avenue Etobicoke/Toronto, Ontario
TITLE	BOREHOLE LOCATION PLAN

GRAIN SIZE DISTRIBUTION

CLAYEY SILT with SAND (FILL)

FIGURE 1



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	F1	4	154.8

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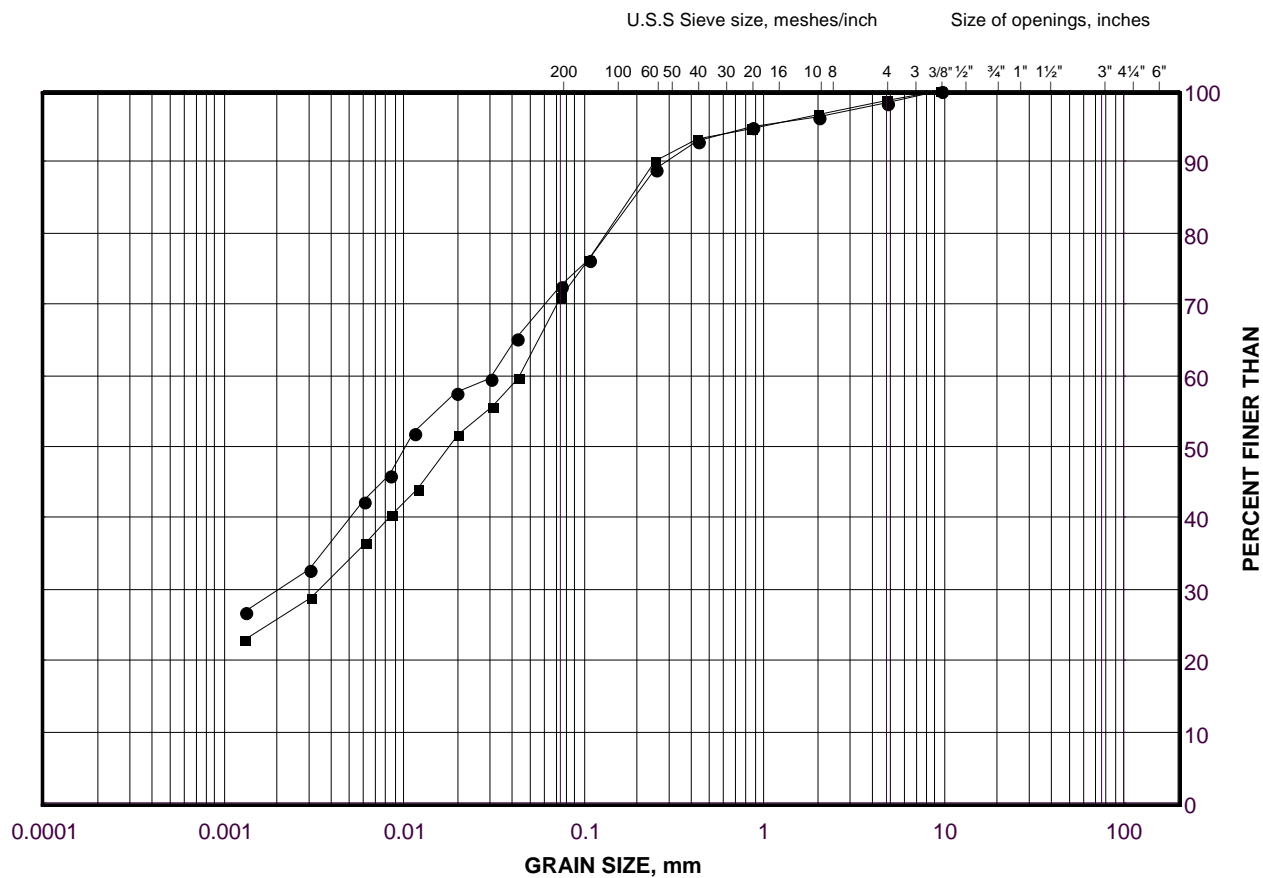
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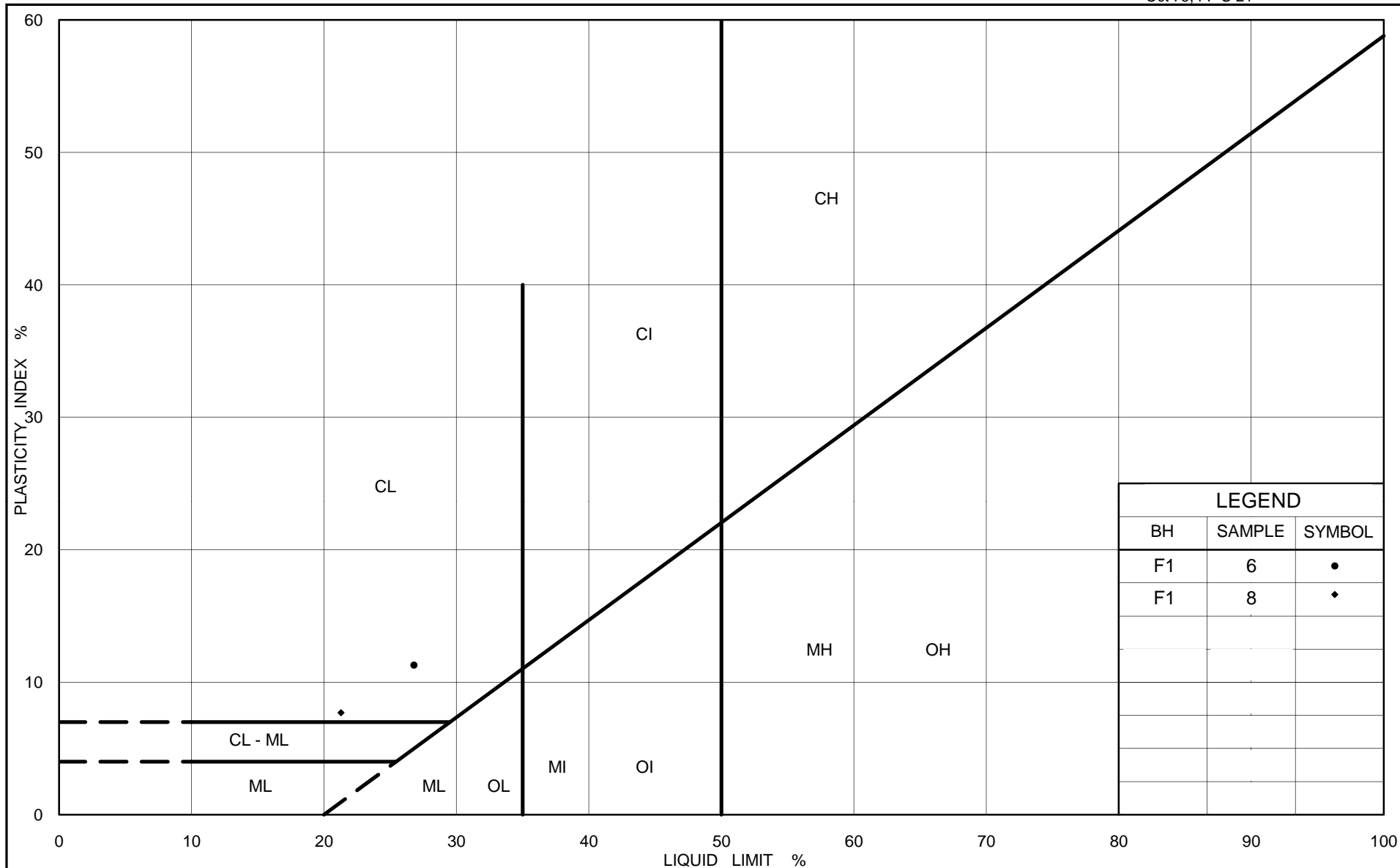
Date: 13-Apr-11

GRAIN SIZE DISTRIBUTION

CLAYEY SILT with SAND (TILL)

FIGURE 2





Ministry of Transportation

Ontario

PLASTICITY CHART CLAYEY SILT with SAND (TILL)

Figure No. 3

Project No. 07-1186-0522 (4565)

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