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DIST. 6 REGION

W.P. No. 138-87-01

CONT. No. 90-60

W. O. No.

STR. SITE No. 37-1170

HWY. No. 400

LOCATION Ramp 407 E-W to 400 S
over C.W.R (Bridge #4)

No. of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

G.I.-30 SEPT. 1976

FOUNDATION INVESTIGATION REPORT

CONTRACT NO 90-60



Ministry of
Transportation

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NOTE: For the purposes of this contract, these reports supersede all other Foundation Investigation Reports prepared by or for the Ministry in connection with the above-noted projects.

EXPLANATION OF TERMS USED IN REPORT

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N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \bar{N}

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON "A" SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND/OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
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'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
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
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{\min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	KN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	KN/m^3	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	KN/m^3	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	KN/m^3	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	KN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL	e_{\max}	1, %	VOID RATIO IN LOOSEST STATE	j	KN/m^2	SEEPAGE FORCE
γ'	KN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

FOUNDATION INVESTIGATION REPORT

For

Ramp Structure 407 EW to 400 S

(Over CNR) - Bridge #4

W.P. 138-87-01, Site #37-1170

Hwy. 400/407, District 6, Toronto

INTRODUCTION

This report summarizes the results obtained from a Foundation Investigation implemented at the aforementioned site. A three span structure (15 m-19 m-15 m) will carry traffic over the CNR tracks from 407 EW to 400 S. This report is applicable to the structure and its related retaining walls and approaches.

SITE DESCRIPTION AND GEOLOGY

The site is located approximately 40 metres west of the existing CNR Overhead at Highway 400 in the Town of Vaughan. The CNR tracks bisect the proposed bridge providing rail transportation in an east-west direction.

The terrain surrounding the site is generally flat. Side slopes adjacent to the tracks illustrate the excavation cut required in advancing the CNR tracks. Hydro transmission towers constitute the Hydro corridor approximately 50 metres north of the site and the Steeles ramp to 400 S is located approximately 50 metres south of the site. A single level industrial building exists approximately 1 km northwest of the site.

Geologically, the site is located in the physiographic region known as the Peel Plain. It consists of a bevelled till plain with a gently undulating rolling surface and limited relief. The till plain was deposited by the advance and retreat of the Wisconsin ice sheet during the Pleistocene epoch (over 5,000 years ago).

FIELD INVESTIGATION

Difficulty in obtaining access to the CNR owned area of the site resulted in the field work being divided into two segments. The initial segment involved advancing four sampled boreholes accompanied by dynamic cone penetration tests

outside the CNR property between 88 01 11 and 88 01 14. The subsequent investigation was implemented within the CNR right-of-way between 88 03 24 and 88 03 28 and consisted of six sampled boreholes accompanied by dynamic cone penetration tests.

Continuous flight hollow stem and solid stem auger equipment was used to advance the boreholes with subsoil samples retrieved by a split spoon sampler in accordance with the Standard Penetration Test (ASTM D1586). Washboring methods were required upon encountering the silt-sandy silt layer at boreholes 3 and 4 at elevation 178.5 metres. The samples were identified in the field and then transported to the laboratory for applicable testing on selected samples.

Water levels were obtained in the open boreholes until approximate stabilized levels were observed.

Survey information related to location and elevation of boreholes was provided by Central Region Surveys and Plans.

LABORATORY ANALYSES

To identify the behaviour, gradation and property of the soil, laboratory analyses consisted of:

- 1) Atterberg Limit tests/grain size analyses
- 2) Unit weight determination
- 3) Natural moisture content determination

SUBSURFACE CONDITIONS

In general, reasonably competent and uniform subsurface conditions were encountered across the site. Underlying a thin veneer of topsoil (100 mm), a deposit of clayey silt, some sand and a trace of gravel (glacial till) was founded. The deposit is interbedded with a confined silt-sandy silt layer that was sampled at depths ranging from 4.6 m at the location of the proposed piers

to 7.8 at the remainder of the site. This lacustrine deposit extends to a maximum thickness of 2.0 metres. The consistency of the clayey silt deposit (glacial till) varies from stiff to hard but is predominantly hard.

The boundaries between the various soil types, in-situ and laboratory test results, as well as stabilized ground water levels, are shown on the attached Record of Borehole Sheets. A plan of the site illustrating the locations and elevations of the boreholes and subsoil stratigraphical sections are provided on Dwg. 1388701-A.*

A detailed description of the subsurface conditions encountered is given below.

Clayey Silt, some sand, trace gravel (Glacial Till)

Explored to a maximum thickness of 15.7 m, a deposit consisting of clayey silt, some sand, trace gravel exists across the site. Throughout the deposit random silt layers and sand seams were encountered. In the upper metre of the stratum, traces of organics were identified.

The main component of the deposit is a clayey silt (CL) with random zones of less cohesive plastic silt (CL-ML). In general, the stratum is considered cohesive. A grain size distribution envelope for the material as determined by mechanical analyses is given in Figure 1. Atterberg Limits were also obtained to evaluate the behaviour of the fine grained portion of the material and the results are plotted in Figure 2. A summary of the indices of the basic cohesive material matrix is provided in Table 1 below. Unit weights are also included.

TABLE 1

	<u>Range</u>	<u>Avg.</u>
Natural Moisture Content (w%)	7.5-23.5	11.6
Liquid Limit (W_L %)	13-32	20.1
Plastic Limit (W_p %)	10-20.5	13.3
Unit Weight (kN/m^3)	21.4-23.3	22.2

* DWG NO 2 OF THE CONTRACT DWG'S

It is evident from the results that the deposit is predominantly of low plasticity. In general, lower moisture contents were observed beneath the cohesionless silt layer founded within the deposit. In addition, the silt content within the till deposit increases beneath the interbedded silt layer and consequently the soil becomes less cohesive and is only slightly plastic.

Boulders and cobbles, although not encountered during the investigation, are characteristic components of till deposits and consequently may be assumed to exist in this deposit.

'N' values obtained as per the Standard Penetration Test indicate that the deposit has a consistency ranging from firm to hard. Generally, the deposit may be considered to be hard. Resistance to driving the split spoon increased beneath the lacustrine confined silt layer where 'N' values were considerably high.

A significant layer of silt interbedded with sand seams exists at elevations ranging from 178.6 m to 179.8 m within the predominant till deposit. This layer is a lacustrine deposit and ranges in denseness from compact to very dense, but is generally in a dense-very dense state. Grain size distribution curves illustrating the gradation of the deposit is provided in Figure 3. The cohesionless layer is water bearing and the fact that the material backed up in the hollow stem augers during drilling indicates that the stratum is perhaps under subartesian head.

GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water level in the open boreholes. Measurements revealed stabilized levels at an elevation ranging from 186.1 metres to 184.4 metres. These elevations correspond to depths below ground surface of 1 to 2 metres at the abutment-retaining wall locations and at the surface at the pier locations. The silt-sandy silt layer confined within the till exhibits a tendency to flow or boil due to conditions of unbalanced hydrostatic head.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of T. Sangiuliano, Foundation Engineer, utilizing equipment owned and operated by Master Soil Drilling, Toronto. This report was written by T. Sangiuliano and reviewed by Mr. M.S. Devata, Chief Foundation Engineer (East).



D. Dundas, P. Eng.
Sr. Foundation Engineer

M. Devata, P. Eng.
Chief Foundation Engineer

APPENDIX

RECORD OF BOREHOLE No 1

METRIC

W P 138-87-01 LOCATION Co-ords. N 4 848 306.8; E 301 814.2 ORIGINATED BY TS
 DIST 6 HWY 400 BOREHOLE TYPE Hollow Stem Auger, Washbore & Cone Test COMPILED BY TS
 DATUM Geodetic DATE 88 01 11 - 12 CHECKED BY

OFFICE REPORT ON SOIL EXPLORATION

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						
186.8	Ground Surface													
0.0	Topsoil													
	Clayey Silt		1	SS	15		186							
	Some Sand		2	SS	15									
	Trace Gravel		3	SS	22									
	(Glacial Till)		4	SS	13		184						21.7	1 6 33 60
	Stiff to V. Stiff		5	SS	70									
	Hard		6	SS	72									
	Random Zones		7	SS	54		182						4	20 60 16
	of Silt		8	SS	41									
			9	SS	54		180							
178.6													20.6	
8.2	Silt with Sand		10	SS	62	*	178							
	V. Dense (Lacustrine)													
177.2			11	SS	120		176							16 25 58 1
9.6			12	SS	100/15 cm		174							
			13	SS	100/15 cm									2 32 50 16
							172							
171.1			14	SS	100									
15.7	End of Borehole													
	*NOTE Soil backed up in augers at 8.2 m. Advance by washboring inside augers.													

RECORD OF BOREHOLE No 2										METRIC		
W P 138-87-01		LOCATION Co-ords. N 4 848 311.1; E 301 830.4				ORIGINATED BY TS						
DIST 6 HWY 400		BOREHOLE TYPE Hollow Stem Auger & Cone Test				COMPILED BY TS						
DATUM Geodetic		DATE 88 01 12				CHECKED BY						
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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER			TYPE	'N' VALUES					
187.3	Ground Surface											
0.0	Topsoil											
	Clayey Silt with Sand, Trace Gravel		1	SS	12							
	Stiff		2	SS	16							
	to V. Stiff		3	SS	18							
	Hard		4	SS	38							
	Brown Grey		5	SS	55							
	(Glacial Till)		6	SS	30							
	Random Zones of Silt		7	SS	46							
			8	SS	30							
179.7	Silt with interbedded Sand Seams, compact to V. Dense (Lacustrine)		9	SS	23							
7.6			10	SS	55							
177.7			11	SS	91							
9.6			12	SS	100	15 cm						
			13	SS	105							
173.1	End of Borehole											
14.2												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 3

METRIC

W P 138-87-01 LOCATION Co-ords. N 4 848 240.0; E 301 830.0 ORIGINATED BY TS
DIST 6 HWY 400 BOREHOLE TYPE Hollow Stem Auger, Washbore & Cone Test COMPILED BY TS
DATUM Geodetic DATE 88 01 13 CHECKED BY

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100					
186.3	Ground Level												
0.0	Topsoil						186						
	Some Organics		1	SS	13		184						
	Clayey Silt		2	SS	9								
	Some Sand		3	SS	14								
	Trace Gravel		4	SS	6								
	(Glacial Till)		5	SS	28								
	Firm to V. Stiff		6	SS	65							23.3	1 20 62 17
	Hard		7	SS	65							22.6	
	Random Zones of Silt		8	SS	38								2 71 23 4
178.7	Sand, Some Silt		9	SS	26								
7.6	Compact - Dense		10	SS	100								3 33 52 12
176.7	(Lacustrine)		11	SS	100/15 cm								3 32 47 18
9.6			12	SS	100/15 cm								
172.3	End of Borehole												
14.0													
	<p><u>*NOTE</u> Soil backed up in augers at 8.5 m. Advance by washboring inside augers.</p>												

RECORD OF BOREHOLE No 4										METRIC			
W P 138-87-01		LOCATION Co-ords. N 4 848 245.0; E 301 846.0				ORIGINATED BY TS							
DIST 6 HWY 400		BOREHOLE TYPE Hollow Stem Auger, Washbore & Cone Test				COMPILED BY TS							
DATUM Geodetic		DATE 88 01 13 - 14				CHECKED BY							
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	W _p	W	W _L			
186.5	Ground Level												
0.0	Topsoil												
	Some Organics	1	SS	16									
	Clayey Silt	2	SS	11									
	Some Sand	3	SS	24									
	Trace Gravel	4	SS	9									
	(Glacial Till)	5	SS	27									
	Stiff to	6	SS	30									
	V. Stiff	7	SS	47									
	Hard	8	SS	92									
	Random Zones of Silt	9	SS	26									
178.9		10	SS	28									
7.6	Silt with Sand Compact	11	SS	100/15 cm									1 37 61 1
176.9	(Lacustrine)	12	SS	100/20 cm									
9.6		13	SS	100									4 31 50 15
172.5													
14.0	End of Borehole												
<p>*NOTE Soil backed up in augers at 8.5 m. Advance by washboring inside augers.</p>													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 5

METRIC

W P 138-87-01 LOCATION Co-ords. N 4 848 295.1; E 301 832.4 ORIGINATED BY TS
 DIST 6 HWY 400 BOREHOLE TYPE Cone Test, Solid Stem Auger COMPILED BY TS
 DATUM Geodetic DATE 88 03 24 CHECKED BY

OFFICE REPORT ON SOIL EXPLORATION

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						
186.5	Ground Surface													
0.0	Clayey Silt Some Sand Trace Gravel (Glacial Till)		1	SS	16		186							
			2	SS	25		184						20.4	0 9 29 62
	Stiff to V. Stiff Hard	Brown Grey	3	SS	25									
			4	SS	27									
			5	SS	42									
	Random Zones of Silt		6	SS	74		182						22.1	1 19 56 24
			7	SS	100									
			8	SS	50		180							
178.9	Silt with Sand Compact (Lacustrine)		9	SS	16		178							
7.6														
177.4			10	SS	110									
9.1														
			11	SS	100	15 cm	176							
			12	SS	100	15 cm	174							7 38 35 20
172.5			13	SS	100	15 cm								
14.0	End of Borehole													

RECORD OF BOREHOLE No 6

METRIC

W P 138-87-01 LOCATION Co-ords. N 4 848 292.0; E 301 820.0 ORIGINATED BY TS
 DIST 6 HWY 400 BOREHOLE TYPE Cone Test, Solid Stem Auger COMPILED BY TS
 DATUM Geodetic DATE 88 03 24 CHECKED BY

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE						
186.8	Ground Surface									
0.0	Clayey Silt with Sand Trace Gravel (Glacial Till)		1	SS	24					
			2	SS	22					
	V. Stiff Hard	Brown Grey	3	SS	27					
			4	SS	55					
			5	SS	51					
	Random Zones of Silt		6	SS	61					
			7	SS	77					
			8	SS	51					
179.2			9	SS	41					
7.6	Silt with Occ. Sand Pockets Dense (Lacustrine)		10	SS	49					
177.7			11	SS	100/15 cm					
9.1			12	SS	100/15 cm					
172.6			13	SS	120					
14.2	End of Borehole									

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 7										METRIC				
W P 138-87-01		LOCATION		Co-ords. N 4 848 284.2; E 301 829.9		ORIGINATED BY TS								
DIST 6 HWY 400		BOREHOLE TYPE		Cone Test, Solid Stem Auger		COMPILED BY TS								
DATUM Geodetic		DATE		88 03 24		CHECKED BY								
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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	WATER CONTENT (%)					
184.4	Ground Surface													
0.0	Stiff Hard		1	SS	14								23.0	2 20 58 20
	Clayey Silt		2	SS	66									
	Some Sand		3	SS	82									
	Trace Gravel		4	SS	62									
	(Glacial Till) Grey		5	SS	41									0 12 58 30
	Random Zones		6	SS	54									
	of Silt		7	SS	21									
179.8	Sandy Silt		8	SS	59									1 49 46 4
4.6	Compact - V. Dense		9	SS	121/	23 cm								
	(Lacustrine)		10	SS	100/	12 cm								
177.8			11	SS	125/	23 cm								
6.6			12	SS	123/	15 cm								
171.9														
12.5	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

+3, x⁵: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 8

METRIC

W P 138-87-01 LOCATION Co-ords. N 4 848 267.0; E 301 834.0 ORIGINATED BY TS
 DIST 6 HWY 400 BOREHOLE TYPE Cone Test, Solid Stem Auger COMPILED BY TS
 DATUM Geodetic DATE 88 03 25 CHECKED BY

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
185.0	Ground Surface										
0.0											
			1	SS	7		184			23.2	1 19 60 20
			2	SS	80						
			3	SS	58						
			4	SS	80						
			5	SS	70						
			6	SS	65						
179.7	Random Zones of Silt		7	SS	70		180				
5.3	Silt with interbedded Sand Seams, V. Dense (Lacustrine)		8	SS	100						
178.0			9	SS	60/8 cm		178				
7.0			10	SS	100/8 cm		176				
			11	SS	60/8 cm		174				
172.4			12	SS	100						
12.6	End of Borehole										

RECORD OF BOREHOLE No 9

METRIC

W P 138-87-01 LOCATION Co-ords. N 4 848 259.0; E 301 841.0 ORIGINATED BY TS
 DIST 6 HWY 400 BOREHOLE TYPE Cone Test, Solid Stem Auger COMPILED BY TS
 DATUM Geodetic DATE 88 03 25-28 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT Y kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100							W _p	W	W _L
								SHEAR STRENGTH kPa									
								○ UNCONFINED	+ FIELD VANE	WATER CONTENT (%)							
								● QUICK TRIAXIAL	x LAB VANE	10	20	30					
186.5	Ground Surface																
0.0	Clayey Silt Some Sand Trace Gravel (Glacial Till)		1	SS	13		186										
			2	SS	15		184						21.4	4 26 53 17			
	Stiff to V. Stiff	Brown Grey	3	SS	28												
	Hard		4	SS	14												
			5	SS	44		182			120/10 cm							
			6	SS	40												
	Random Zones of Silt		7	SS	65		180										
			8	SS	60												
178.9			9	SS	48		178							1 7 72 20			
7.6	Silt Occ. Sand Seams Dense (Lacustrine)		10	SS	31												
176.9							176										
9.6			11	SS	100/	15 cm											
			12	SS	100/	15 cm	174										
172.5			13	SS	100/	15 cm								1 36 50 13			
14.0	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 10

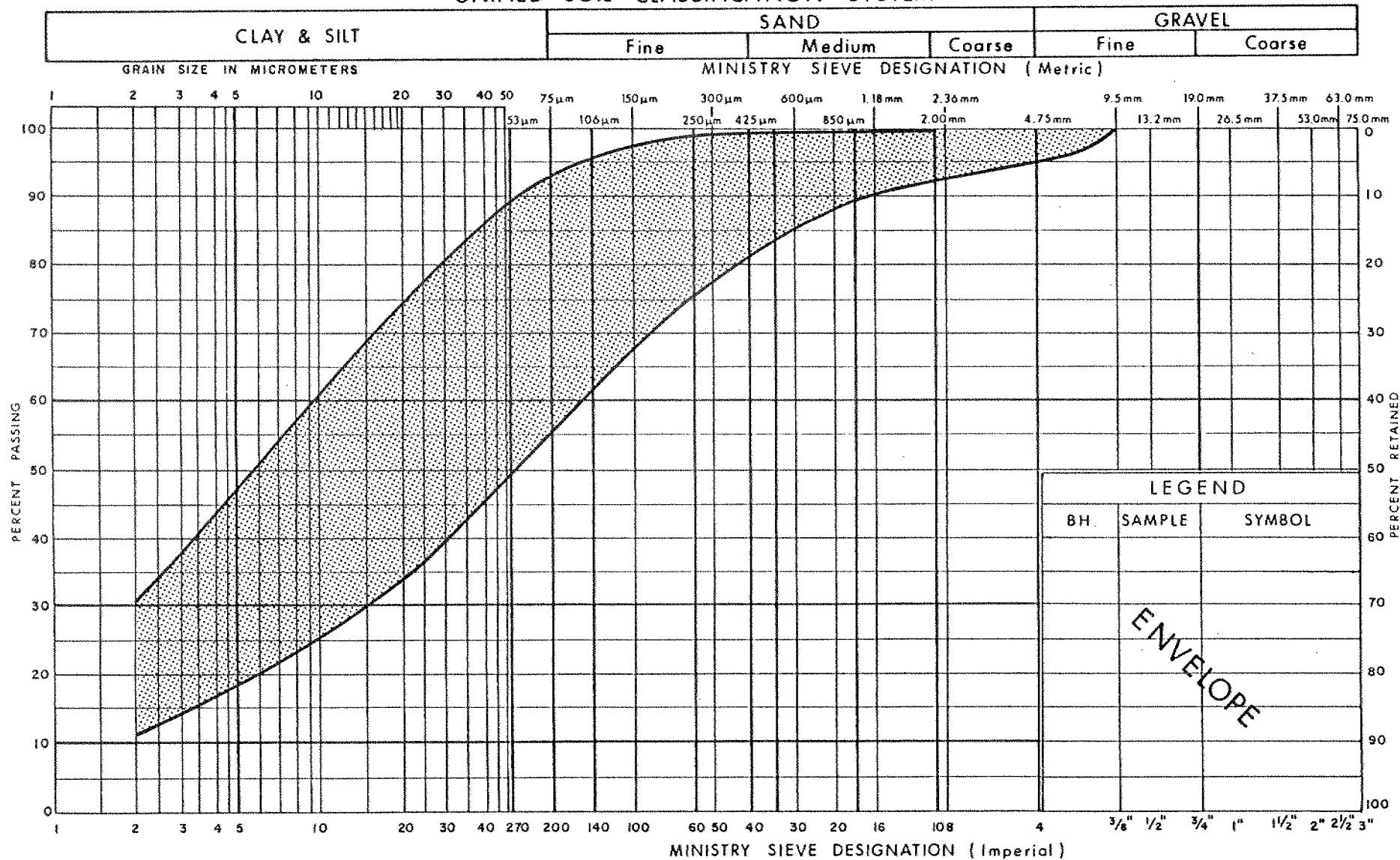
METRIC

W P 138-87-01 LOCATION Co-ords. N 4 848 255.9; E 301 828.5 ORIGINATED BY TS
 DIST 6 HWY 400 BOREHOLE TYPE Cone Test, Solid Stem Auger COMPILED BY TS
 DATUM Geodetic DATE 88 03 28 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
186.8	Ground Surface												
0.0													
	Brown Grey v. Stiff to Hard Hard Clayey Silt Some Sand Trace Gravel (Glacial Till) Random Zones fo Silt		1	SS	18								
			2	SS	16								
			3	SS	38								
			4	SS	17								
			5	SS	51								
			6	SS	120								
			7	SS	70/	15 cm							
			8	SS	70								
179.2													
7.6	Silt with Sand V. Dense		9	SS	78								
177.2	(Lacustrine)		10	SS	70								
9.6													
			11	SS	100/	15 cm							
174.3													
			12	SS	100/	15 cm							
12.5	End of Borehole												

OFFICE REPORT ON SOIL EXPLORATION

UNIFIED SOIL CLASSIFICATION SYSTEM

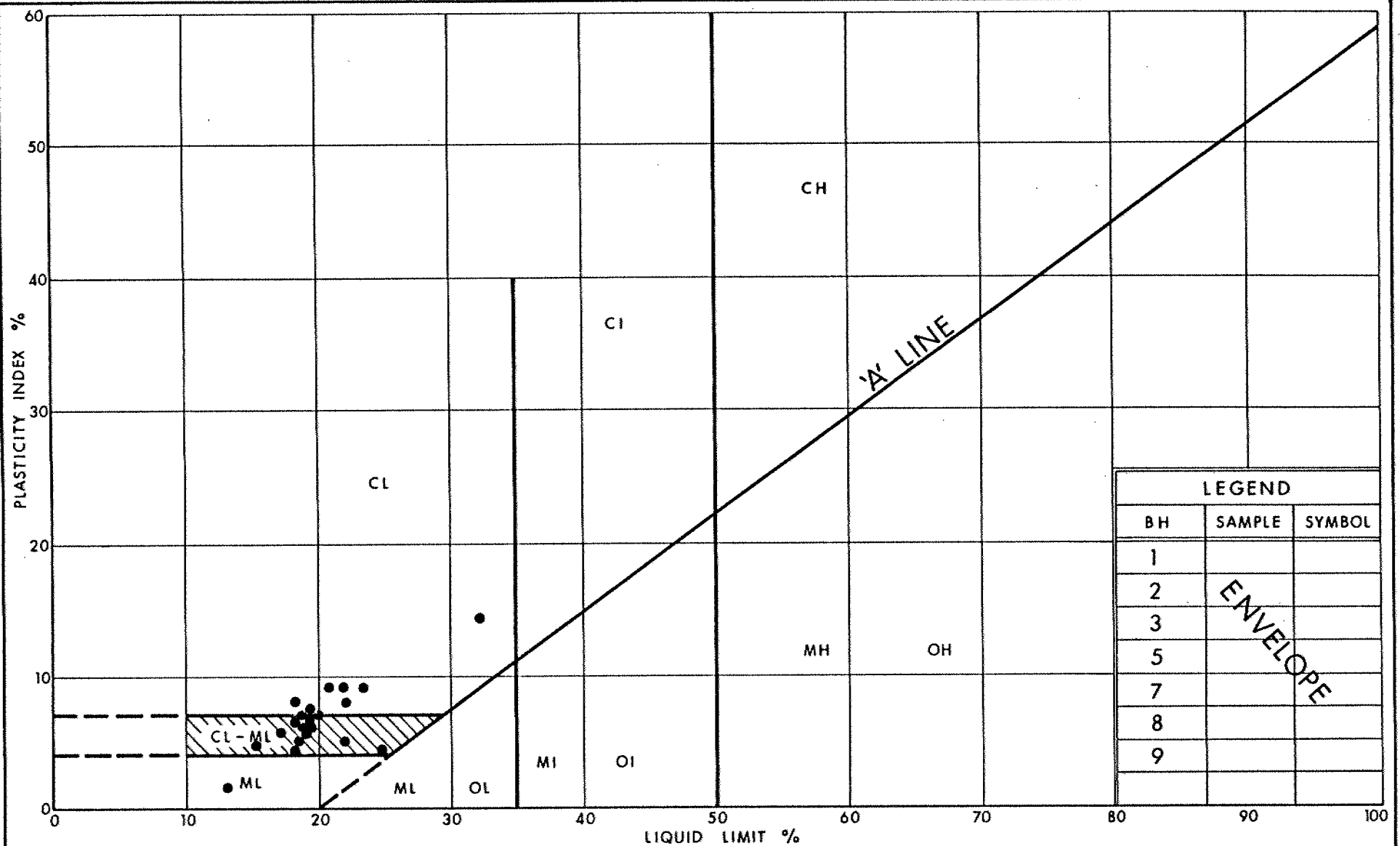

 Ministry of
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Ontario

GRAIN SIZE DISTRIBUTION
 CLAYEY SILT WITH/SOME SAND, TRACE GRAVEL
 (Glacial Till)

FIG No 1

W P 138-87-01



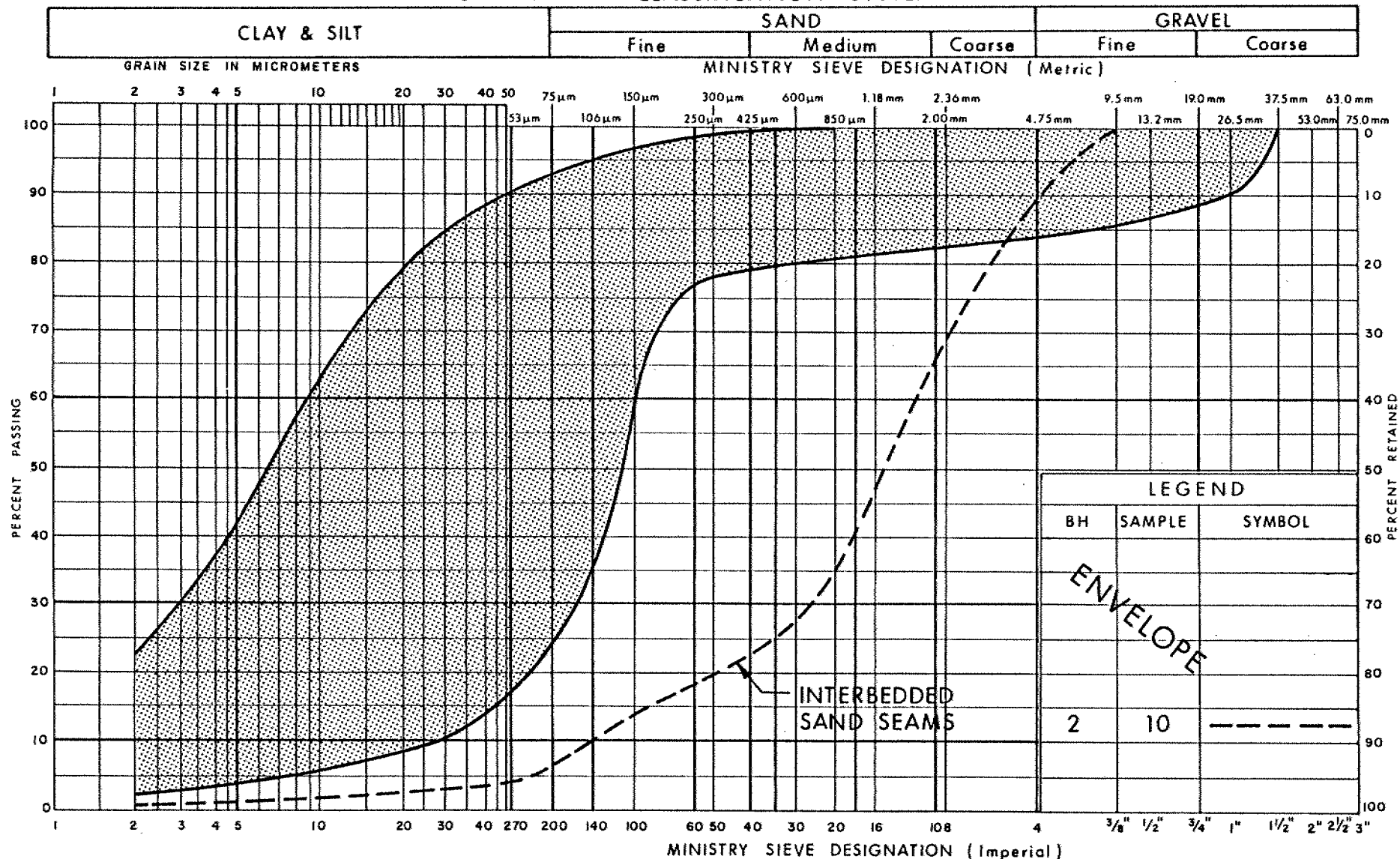
Ministry of
Transportation
Ontario

PLASTICITY CHART CLAYEY SILT, SOME /WITH SAND, TRACE GRAVEL (Glacial Till)

FIG No 2

W P 138-87-01

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

Ontario

GRAIN SIZE DISTRIBUTION
SILT WITH SAND, TRACE GRAVEL
AND INTERBEDDED SAND SEAMS

FIG No 3

W P 138-87-01

FOUNDATION INVESTIGATION REPORT

For

Ramp 407 EW to Hwy. 400 S

Over Steeles Avenue

Structure #1

W.P. 138-87-02, Site 37-1169

District 6, TorontoINTRODUCTION

This report summarizes the information obtained from a foundation investigation carried out at the above mentioned site during the periods of December 14 to December 17, 1987.

As described in our previous Foundation Investigation Report (W.P. 138-87-03 & 05, April 1988), ten boreholes (Boreholes 1 to 8 and Boreholes #2-1 and #2-2) were advanced and sampled during the various time as part of the foundation investigation for the Hwy. 400 over the Steeles Avenue. These boreholes extended to depths between 8.1 and 18.6 metres below the ground surface. The results obtained from these boreholes are utilized in this report (Boreholes 1, 5 and 7).

During the December of 1987, three boreholes (Boreholes #1-1, #1-2 and #1-3) were advanced and sampled as part of this project by means of hollow stem augers and washboring techniques. These boreholes extended down to depths between 9.6 and 18.8 metres below the ground surface.

This report contains factual information pertaining to the foundation of a new 2-span structure shown on Drawing No. 1388702-A *

SITE DESCRIPTION AND GEOLOGY

The site is located immediately west of existing bridge for Highway 400 where it crosses Steeles Avenue. The existing structure will be lengthened easterly and a new rigid frame structure will be constructed north and parallel to the existing structure. At this location, Steeles Avenue and Highway 400 have elevations between 186.5 and 193.0 m respectively. The existing bridge over the

* DWG NO 2 OF THE CONTRACT DWG'S

Steeles Avenue is a 21.3 x 43.5 metres single span frame bridge constructed with earth embankments up to 6.5 metres in height.

This site is located in the physiographic region known as the "Peel Plain" as described by the physiography of South Ontario (Chapman and Putnam, 1984). This region is characterized by a level to gently undulating topography sloping gradually towards the south. The underlying soil consists of a hard layer of glacial till overlying very dense sandy silt to silty sand. Land use is mainly for industrial purposes.

SUBSURFACE CONDITIONS

General

The subsoil conditions encountered across the site were generally uniform consisting primarily of two distinct deposits. The upper layer consists of clayey silt to silt with sand and a trace of gravel which extends down to the elevations between 179.8 m at BH #1-2 and 182.0 m at BH #1-1 as shown on the section in Drawing No. 1388702-A.* The thickness of this layer varies between 5.7 m at BH #1-2 location and 6.4 m at BH #1 location. Underneath this clayey silt to silt, very dense sandy silt to silty sand with occasional sand layers is present. Approximately 11.0 metres of this very dense material was proven. These deposits are glacial origin. The fill material was encountered at two borehole locations (BH #1, #1-2 and #1-3). This material is composed of silty clay with a depth up to 2.1 metres.

More detailed description of the two distinct subsoil deposits and the fill material will be presented.

1) Clayey Silt to Silt

A layer of clayey silt to silt with sand and a trace of gravel extends from the ground surface to depths between 6.1 and 8.2 metres. The material changes in colour from brown to grey at approximately elevation 184.0 on the north side of Steeles Avenue and 179.0 m on the south side of the road.

* DWG NO 2 OF THE CONTRACT DWG'S

The results from laboratory tests performed on this material are summarized as follows:

<u>Properties</u>	<u>Range (%)</u>
Moisture Content (w)	8.5-19.5
Liquid Limit (w_L)	15.5-31.0
Plastic Limit (w_p)	10.0-13.0
Plasticity Index (I_p)	4-17.5

The Atterberg Limit Test results are illustrated on the plasticity chart (See Figure 1). From the chart it is evident that the layer can be classified as an inorganic clayey silt to silt with low plasticity (CL or CL-ML).

Grain size distribution tests were carried out on these materials. Figure 3 in the Appendix shows that the result in envelope form.

Standard Penetration Test 'N' values between 11 and over 100 indicated that soil can be interpreted as being stiff to hard.

2) Sandy Silt to Silty Sand

Silty sand to sandy silt was encountered below the clayey silt layer. All samples recovered from the north side of Steeles Avenue had a grey colour whereas samples recovered above elevation about 186.0 meters on the south side were brown in colour. Samples taken below elevation about 180.0 metres on the south side were grey in colour.

Grain size distribution analysis indicates that the soil varies between a silty sand and sandy silt. Trace of clay and gravel are also present. This layer is basically non-plastic. The Atterberg Limit Test results are shown on the plasticity chart (See Figure 2). From the chart it is evident that the layer can be classified as sandy silt to silty sand (ML). Figure 4 in the Appendix shows the results of grain size distribution tests in envelope form.

In this stratum, the 'N' values ranged from 23 to over 100 blows/0.3 m indicating a state of compaction described as dense to very dense.

3) Fill Material

The fill material was encountered on the north side of Steeles Avenue at two borehole locations (BH #1, #1-2 and #1-3). This fill consists of a brown silty clay or clay silt with some sand and trace of gravel. The thickness of this layer varies from 1.4 metres at BH #1 and to 2.1 metres at BH #1-3 as shown on borehole logs. No Atterberg Limit Tests and grain size distribution analysis were carried out. However, through visual observation, it is apparent that the fill material is similar to the embankment fill for Hwy. 400 which is classified to silty clay to clayey silt.

Standard Penetration Test 'N' values between 8 and 42 indicate that the fill material is in a stiff to hard state.

The results of all field and laboratory testing, along with a summary of the subsoil conditions encountered in each borehole are shown on the Record of Borehole Sheets (See Appendix). Stratigraphical profiles are shown on Drawing No. 1388702-A.* Also shown on this drawing is a generalized plan of the site area showing the locations of the boreholes with respect to the relevant structures.

GROUNDWATER CONDITIONS

Groundwater conditions were observed through the measurements of water levels in the open boreholes.

Groundwater level in the borings was found to range between elevation 182.2 m at BH #1-1 and elevation 183.8 at BH #1-3 about 4.5 metres below the original ground surface.

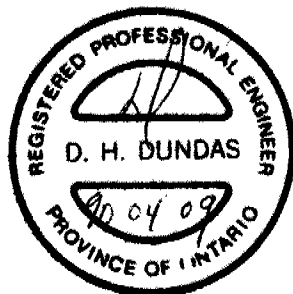
There are pockets of silt and sand within overburden which are water bearing and exhibit a tendency to boil under conditions of unbalanced hydrostatic head.

* DWG NO 2 OF THE CONTRACT DWG'S

MISCELLANEOUS

The fieldwork for this investigation was carried out during the period of 87-12-14 to 87-12-17 under the supervision of Tae C. Kim. The equipment was owned and operated by Master Soil Investigation Toronto.

This report was written by T.C. Kim, Foundation Engineer and reviewed by M. Devata, Chief Foundation Engineer (East).



D. Dundas

D. Dundas, P. Eng.
Sr. Foundation Engineer

M. Devata

M. Devata, P. Eng.
Chief Foundation Engineer

APPENDIX

RECORD OF BOREHOLE No 1

METRIC

W P 138-87-02 LOCATION Coordinates N 4 847 842.0; E 301 951.0 ORIGINATED BY MD
 DIST 6 HWY 400 BOREHOLE TYPE Washbore & Cone Test COMPILED BY
 DATUM Geodetic DATE 1959 06 11 CHECKED BY

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						
189.4	Ground Level													
0.0	Clayey Silt (Fill)													
188.2														
1.2	Clayey Silt to Silt With Sand, Trace of Gravel Occasional Silty Sand Layers Hard (Glacial Till)		1	SS	48								23.6	
			2	SS	60								24.6	
			3	SS	155								24.4	
			4	SS	110								22.9	
			5	SS	151									
181.8			6	SS	160									
7.6			7	SS	167									
			8	SS	160									
			9	SS	160									
			10	SS	170								25.5	
			11	SS	-									
			12	SS	160									
173.5														
15.9	Sand with Gravel Very Dense													
170.8			13	SS	135									
18.6	End of Borehole													
	NOTE: This borehole was done prior to construction of existing bridge. Therefore soil inform- ation above Elev. 185± does not apply.													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 5

METRIC

W P 138-87-02 LOCATION Co-Ords N 4 847 874.0; E 301 932.0 ORIGINATED BY KM
 DIST 6 HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY KM
 DATUM Geodetic DATE 81 02 10 CHECKED BY _____

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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40						60	80	100	WATER CONTENT (%)	
								SHEAR STRENGTH							10	20	30		

186.3	Ground Level													
0.0	Clayey Silt to Silt Some to <u>Brown</u> Trace of Sand <u>Grey</u> Trace of Gravel Occ. Silty Sand Layers Hard (Glacial Till)		1	SS	70	*								
			2	SS	100/	28 cm								
			3	SS	100/	20 cm								
			4	SS	49									
			5	SS	97									
			6	SS	59									
180.1			7	SS	100/	20 cm								
6.2	Sandy Silt Very Dense													
178.2			8	SS	100/	20 cm								
8.1	End of Borehole													
	* W.L. Not Established													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 7

METRIC

W P 138-87-02 LOCATION Co-ords N 4 847 825.0; E 301 945.0 ORIGINATED BY KM
 DIST 6 HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY KM
 DATUM Geodetic DATE 81 02 10-11 CHECKED BY

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100					
188.4	Ground Level												GR SA SI CL
0.0	Clayey Silt to Silt With Sand and Gravel Occ. Silty Sand Layers Very Stiff to Hard (Glacial Till)					*	188						1 60 36 3 2 35 59 4 1 42 52 5 9 35 56 0
			1	SS	19								
			2	SS	34								
			3	SS	52								
			4	SS	100/	15 cm							
			5	SS	100/	25 cm							
			6	SS	44								
	7	SS	100/	13 cm									
182.3	Sandy Silt to Silty Sand Very Dense Brown Grey		8	SS	100/	20 cm	182						
6.1			9	SS	100/	15 cm							
			10	SS	100/	10 cm							
			11	SS	100/	28 cm							
178.8	End of Borehole												
9.6	* W.L. Not Established												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 1-1

METRIC

W P 138-87-02 LOCATION Co-ords. N 4 847 820.5; E 301 932.7 ORIGINATED BY TCK
DIST 6 HWY 400 BOREHOLE TYPE HS Auger and Cone Test COMPILED BY TCK
DATUM Geodetic DATE 1987 12 17 CHECKED BY

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
188.2	Ground Level										
0.0	Silty Clay		1	SS	12		188				
	Clayey Silt to Silt with Sand		2	SS	11		186				4 29 51 16
	Trace of Gravel		3	SS	30						
	Occ. Silty Clay and Silty Sand Layers		4	SS	55						
	Brown Grey		5	SS	25						
	Stiff to Hard (Glacial Till)		6	SS	44						5 20 57 18
182.0			7	SS	46						
6.2	Sandy Silt to Silty Sand		8	SS	107		182				
	Trace of Clay and Gravel		9	SS	125						2 23 70 5
	Very Dense						180				
178.6			10	SS	128						
9.6	End of Borehole										

RECORD OF BOREHOLE No 1-2

METRIC

W P 138-87-02 LOCATION Co-ords. N 4 847 859.0; E 301 930.0 ORIGINATED BY TCK
 DIST 6 HWY 400 BOREHOLE TYPE HS Auger and BX Casing and Cone Test COMPILED BY TCK
 DATUM Geodetic DATE 1987 12 16 & 17 CHECKED BY

OFFICE REPORT ON SOIL EXPLORATION

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40						60	80	100	WATER CONTENT (%)		
								SHEAR STRENGTH kPa												
							○ UNCONFINED + FIELD VANE													
							● QUICK TRIAXIAL x LAB VANE													
186.9	Ground Level													GR SA SI CL						
0.0	Silty Clay (Fill)		1	SS	8		186							5 33 48 14						
185.5			2	SS	34															
1.4	Brown Silty Sand		3	SS	200	10 cm														
	Grey Clayey Silt to Silt with Sand		4	SS	67		184													
	Trace of Gravel		5	SS	87															
	Occ. Silty Sand Layers		6	SS	70	87 12 17	182							2 16 63 19						
	Hard (Glacial Till)		7	SS	74															
179.8			8	SS	100		180													
7.1	Sandy Silt to Silty Sand		9	SS	86									2 46 51 1						
			10	SS	119		178													
	Brown Sand with Some Gravel		11	SS	43		176							10 81 8 1						
	Trace of Clay and Gravel		12	SS	108		174													
172.7	Very Dense		13	SS	127															
14.2	End of Borehole																			

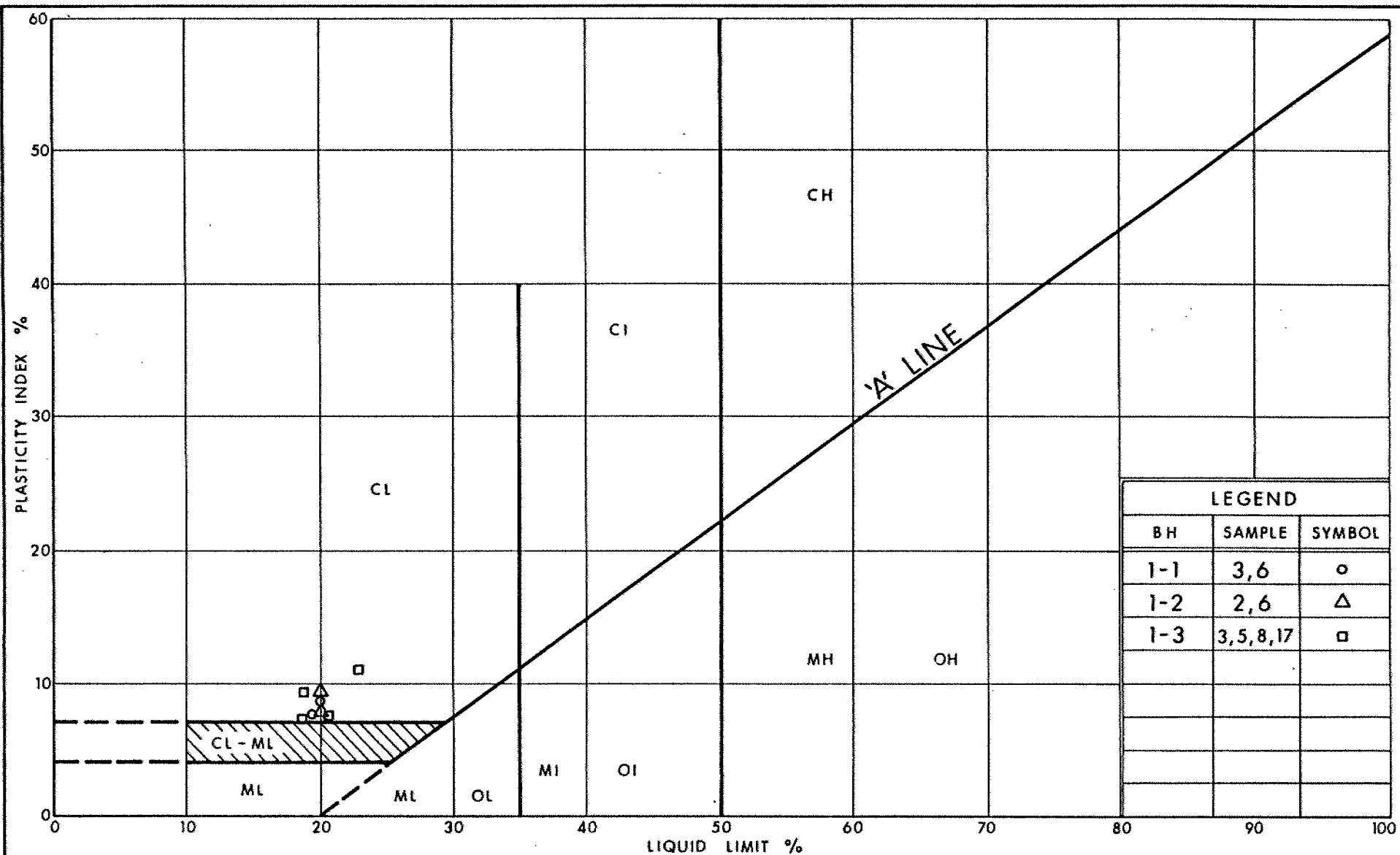
RECORD OF BOREHOLE No 1-3

METRIC

W P 138-87-02 LOCATION Co-ords N 4847 870.5; E 301 918.5 ORIGINATED BY TCK
 DIST 6 HWY 400 BOREHOLE TYPE HS Auger and Cone Test COMPILED BY TCK
 DATUM Geodetic DATE 1987 12 14 and 16 CHECKED BY

OFFICE REPORT ON SOIL EXPLORATION

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						
188.3	Ground Level													GR SA SI CL
0.0	Silty Clay (Fill)		1	SS	42		188							
186.2			2	SS	13		186							4 28 48 20
2.1	Clayey Silt to Silt With Sand Trace of Gravel Occ. Silty Sand Layers Very Stiff to Hard (Glacial Till)		3	SS	23		184							2 29 55 14
			4	SS	31									
			5	SS	71									
			6	SS	66									
			7	SS	80									
			8	SS	57									4 24 62 10
180.1	Brown		9	SS	36		182							
8.2	Grey		10	SS	144		180							3 43 53 1
			11	SS	87									
			12	SS	26		178							
	Grey Brown Sand Some Silt Trace of clay and Gravel		13	SS	23		176							
	Grey		14	SS	72		174							3 83 13 1
	Sandy Silt to Silty Sand Trace of Gravel and Clay		15	SS	154/	15 cm	172							6 36 49 9
	Compact to Very Dense		16	SS	272									
169.5			17	SS	186		170							4 23 52 24
18.8	End of Borehole													

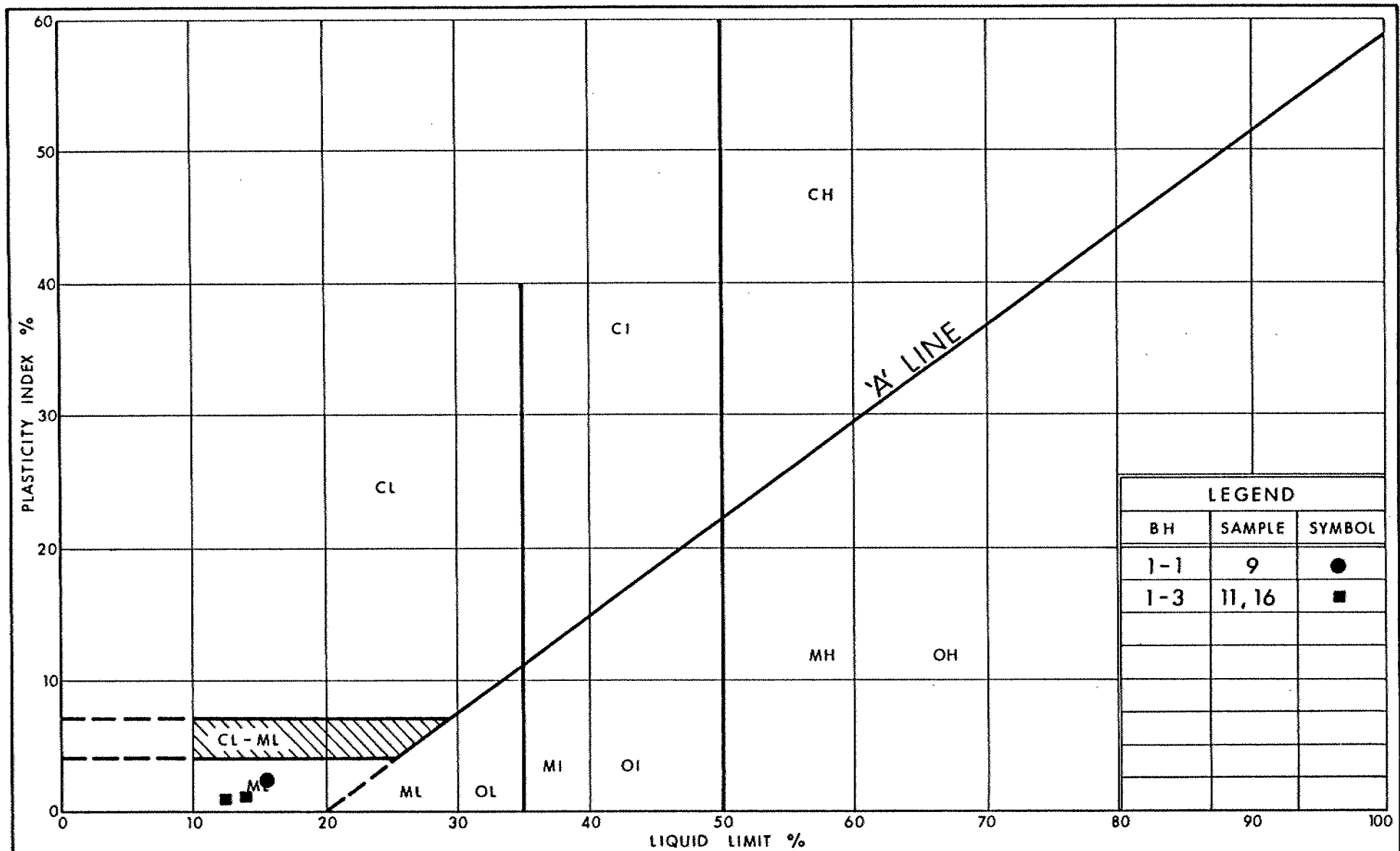


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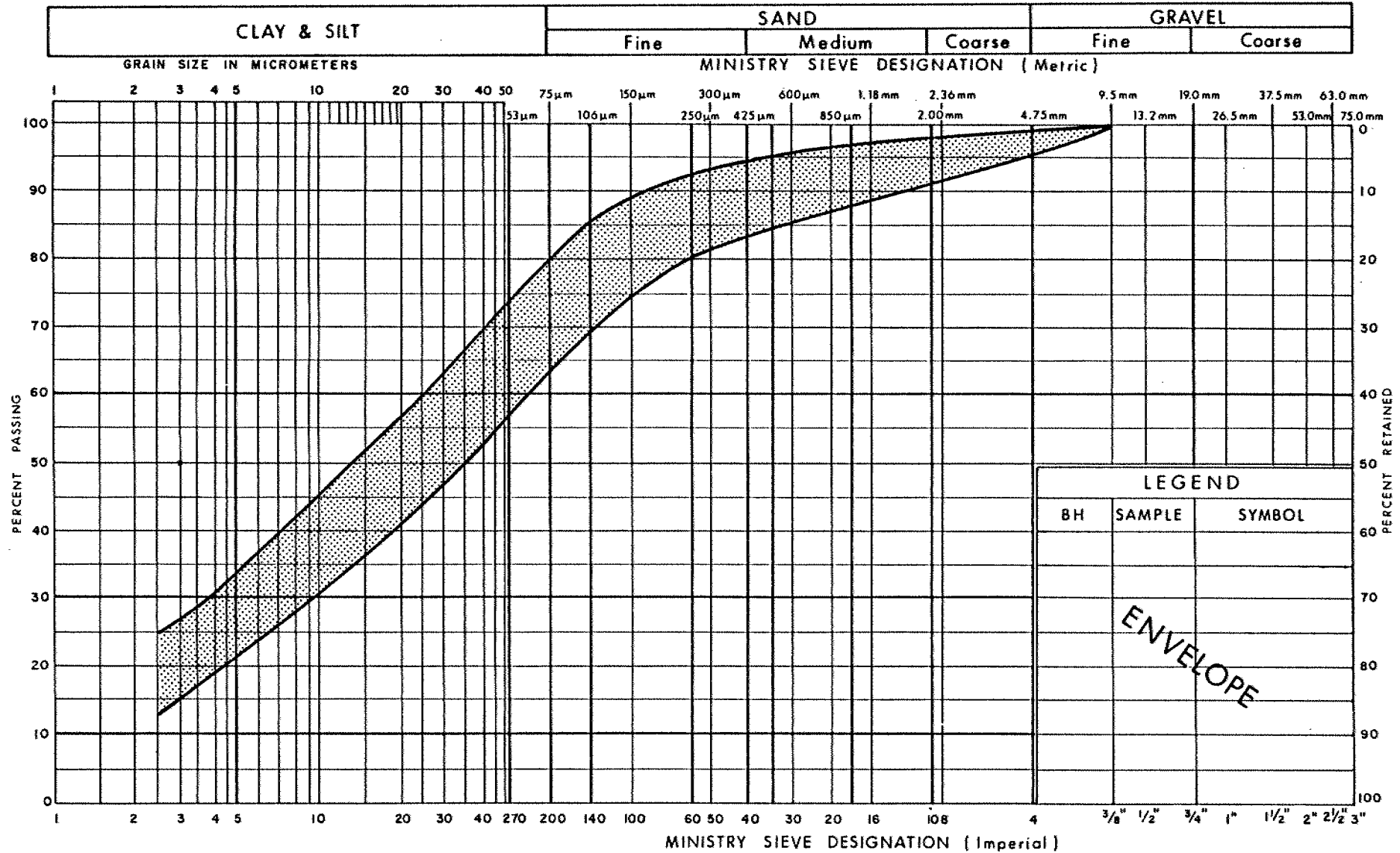
PLASTICITY CHART CLAYEY SILT TO SILT

FIG No 1

W P 138-87-02



UNIFIED SOIL CLASSIFICATION SYSTEM



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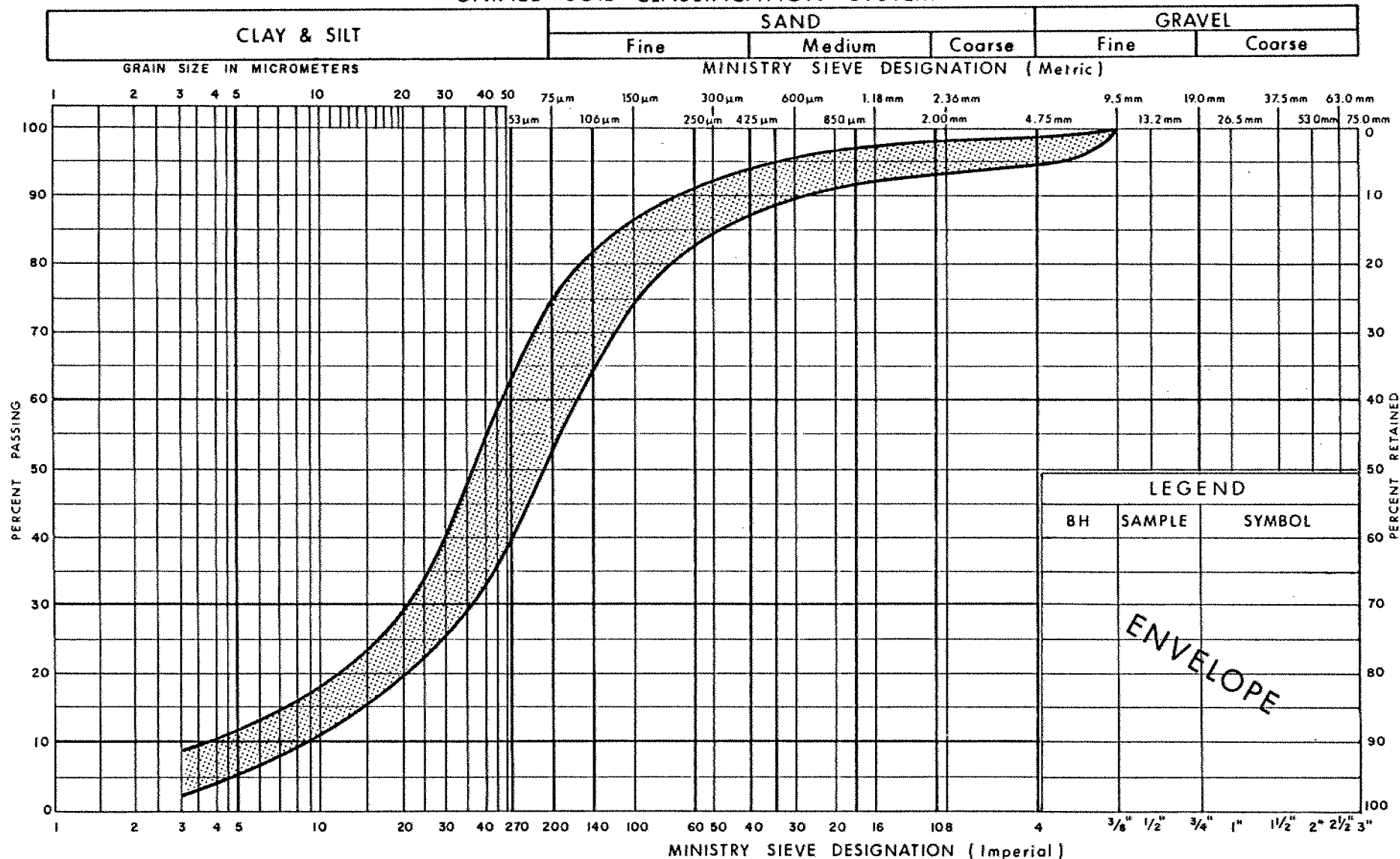
Ontario

GRAIN SIZE DISTRIBUTION CLAYEY SILT TO SILT

FIG No 3

W P 138-87-02

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SANDY SILT TO SILTY SAND

FIG No 4

W P 138-87-02

FOUNDATION INVESTIGATION REPORT
For
Highway 400 Over Steeles Avenue
Structure #2
W.P. 138-87-03 Site No. 37-270 R
District 6, Toronto

INTRODUCTION

This report summarizes the information obtained from a foundation investigation carried out at the above mentioned site during the periods of June 11 to June 20, 1959, February 10 to February 11, 1981, and December 14 to December 18, 1987.

Four boreholes were drilled and sampled in June of 1959 as part of the foundation investigation prior to the construction of the original Hwy. 400 structure. All four boreholes were advanced using a standard diamond drill and conventional washboring techniques. All of the boreholes extended to depths of 18.7 metres below the ground surface. The results obtained from these boreholes (Boreholes 1 to 4) are utilized in this report.

Additional four boreholes (Boreholes 5 to 8) were advanced and sampled in February of 1981 as part of lengthening the existing structure westerly by means of a continuous flight auger machine equipped within solid and hollow stem augers. These boreholes extended to depths between 8.1 and 9.6 metres below the ground surface. The information from these boreholes is also utilized in this report.

During the December of 1987, two additional boreholes (Boreholes #2-1 and #2-2) were advanced and sampled as part of this project by means of hollow stem augers and washboring techniques. These boreholes extended down to depths between 17.0 and 18.6 metres below the ground surface.

This report contains factual information pertaining to the foundations of lengthening of the existing structure and a new rigid frame structure shown on Drawing No. 1388703-A *

* DWG NO 2 OF THE CONTRACT DWG'S

SITE DESCRIPTION AND GEOLOGY

The site is located on Hwy. 400 where it crosses the existing Steeles Avenue. The existing structure will be lengthened easterly and a new rigid frame structure will be constructed north and parallel to the existing structure. At this location, Steeles Avenue and Highway 400 have elevations between 186.5 m and 193.0 m respectively. The existing bridge over the Steeles Avenue is a 21.3 x 43.5 metres single span rigid frame bridge constructed with earth embankments up to 6.5 meters in height.

The site is located in the physiographic region known as the "Peel plain" as described by the Physiography of Southern Ontario (Chapman and Putnam, 1984). This region is characterized by a level to gently undulating topography sloping gradually towards the south. The underlying soil consists of a hard layer of glacial till overlying very dense silty sand to sandy silt. Land use is mainly for industrial purposes.

SUBSURFACE CONDITIONS

General

The subsoil conditions encountered across the site were generally uniform consisting primarily of two distinct deposits. The upper layer consists of a clayey silt to silt with sand and a trace of gravel which extends down to the elevations between 179.2 m at BH #3 and 182.4 m at BH #7 as shown on the sections (Drawing No. 1388703-A) *. The thickness of this layer varies between 4.6 m at BH #2-2 location and 7.8 m at BH #3 location. Underneath this clayey silt to silt, very dense silty sand to sandy silt with the occasional sand layers is present. Approximately 11.5 metres of this very dense material was proven. These deposits are of glacial origin.

* DWG NO 2 OF THE CONTRACT DWG'S

The embankments of the existing structure are composed by approximately 6.5 metres of sand and clayey silt fill materials.

More detailed description of the two distinct subsoil deposits and the embankment fill material will be presented.

1) Clayey Silt to Silt

A layer of clayey silt to silt with sand and a trace of gravel extends from the ground surface to depths between 4.6 and 7.8 metres. The material changes in colour from brown to grey at approximately elevation 184.0 m on the north side of Steeles Avenue and 179.0 m on the south side of the road (at BH #4, elevation 186.0 m).

The results from laboratory tests performed on this material are summarized as follows:

<u>Properties</u>	<u>Range (%)</u>
Moisture Content (w)	8.5 - 19.5
Liquid Limit (w_L)	15.5 - 31.0
Plastic Limit (w_p)	10.0 - 13.0
Plasticity Index (I_p)	4 - 17.5

The Atterberg Limit Test results are illustrated on the Plasticity Charts (See Figure 1 and 2). From the charts it is evident that the layer can be classified as an inorganic clayey silt to silt with low plasticity (CL or CL-ML).

Grain size distribution tests were carried out on these materials. Figure 4 in the Appendix shows the result in envelope form.

Standard Penetration Test 'N' values between 13 and over 100 indicated that the soil can be interpreted as being stiff to hard.

2) Sandy Silt to Silty Sand

Silty sand to sandy silt was encountered below the clayey silt layer. All samples recovered from the north side of Steeles Avenue had a grey colour whereas samples recovered above elevation 179.0 metres on the south side were brown in colour. Samples taken below elevation 179.0 metres on the south side were grey in colour.

Grain size distribution analysis indicates that the soil varies between a silty sand and sandy silt. Trace of clay and gravel are also present. This layer is basically non-plastic. The Atterberg Limit Test results are shown on the plasticity chart (See Figure 3). From the charts it is evident that the layer can be classified as sandy silt to silty sand (ML). A gradation limit curve for this particular soil is present in Figure 5.

In this stratum, the 'N' values ranged from 54 to over 100 blows/0.3 m indicating a state of compaction described as very dense.

3) Embankment Fill Material

The soil used in the embankment fills consists of a brown clayey silt with some sand and trace of gravel. Atterberg Limit Tests indicate that the soil can be classified as a clayey silt of low plasticity (CL) (See Figure 2). The test results are summarized below:

<u>Properties</u>	<u>Range (%)</u>
Moisture Content (w)	11.5 - 14.5
Liquid Limit (w_L)	20.0 - 28.0
Plastic Limit (w_p)	10.5 - 15.0
Plasticity Index (I_p)	7.5 - 15.0

From the test results and through visual observation, it is apparent that the embankment fill material is similar to the layer of clayey silt to silt immediately below the existing ground surface. It is therefore likely that the fill material came from the immediate vicinity. Standard Penetration Test 'N' values between 7 and 28 indicate that the fill material is in a firm to very stiff state.

The results of all field and laboratory testing, along with a summary of the subsoil conditions encountered in each borehole are shown on the Record of Borehole Sheets (See Appendix). Stratigraphical profiles are shown on Drawing No. 1388703-A).^{*} Also shown on this drawing is a generalized plan of the site area showing the locations of the boreholes with respect to the relevant structures.

GROUNDWATER CONDITIONS

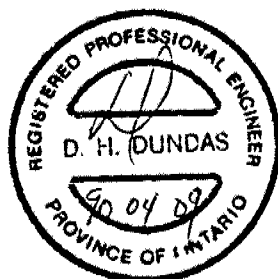
Groundwater conditions were observed through the measurements of water levels in the open boreholes. Groundwater level in the borings was found to range between elevation 180.5 metres at BH #2-2 and elevation 183.3 metres at BH #2-1 about 5.6 metres below the original ground surface.

* DWG NO 2 OF THE CONTRACT DWG'S

MISCELLANEOUS

The fieldwork for this investigation was carried out during the period of 87-12-14 to 87-12-18 under the supervision of Tae C. Kim and Ken Zasitko (Technician). The equipment was owned and operated by Master Soil Investigation Toronto.

This report was written by T.C. Kim, Foundation Engineer and reviewed by M. Devata, Chief Foundations Engineer (East).



D. Dundas
D. Dundas, P. Eng.
Sr. Foundation Engineer

M. Devata
M. Devata, P. Eng.
Chief Foundation Engineer

APPENDIX

RECORD OF BOREHOLE No 1

METRIC

W P 138-87-03 LOCATION Coordinates N 4 847 842.0; E 301 951.0 ORIGINATED BY MD
DIST 6 HWY 400 BOREHOLE TYPE Washbore & Cone Test COMPILED BY _____
DATUM Geodetic DATE 1959 06 11 CHECKED BY _____

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH							WATER CONTENT (%)
								○ UNCONFINED	+ FIELD VANE						
189.4	Ground Level							20 40 60 80 100						GR SA SI. CL	
0.0	Clayey Silt (Fill)	⊠													
188.2															
1.2	Clayey Silt to Silt With Sand, Trace of Gravel Occasional Silty Sand Layers Hard (Glacial Till)		1	SS	48								23.6		
			2	SS	60								24.6		
			3	SS	155								24.4		
			4	SS	110								22.9		
			5	SS	151										
181.8			6	SS	160										
7.6			7	SS	167										
	Brown Grey		8	SS	160										
			9	SS	160										
	Silty Sand to Sandy Silt Very Dense		10	SS	170								25.5		
			11	SS	—										
173.5			12	SS	160										
15.9	Sand with Gravel Very Dense														
170.8			13	SS	135										
18.6	End of Borehole														
NOTE: This borehole was done prior to construction of existing bridge. Therefore soil information above Elev.185± does not apply.															

+3, x5 : Numbers refer to Sensitivity

RECORD OF BOREHOLE No 2

METRIC

W P 138-87-03 LOCATION Coordinates: N 4 847 860.0; E 301 946.5 ORIGINATED BY MD
DIST 6 HWY 400 BOREHOLE TYPE Washbore & Cone Test COMPILED BY
DATUM Geodetic DATE 1959 06 11 CHECKED BY

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH					
188.7	Ground Level							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	10 20 30					
0.0	Clayey Silt (Fill)						188							
187.8														
0.9	Clayey Silt to Silt Some to Trace of Sand Trace of Gravel		1	SS	44							23.8		
			2	SS	75		186					24.0		
			3	SS	89							25.0		
			4	SS	125									
			5	SS	110		184							
			6	SS	157							23.5		
181.4	Occasional Silty Sand Layers Hard (Glacial Till)		7	SS	133		182							
7.3			8	SS	145		180							
178.9	Sandy Silt Very Dense		9	SS	158		178							
9.8			10	SS	163		176							
	Sand With Gravel Very Dense		11	SS	172		174							
174.7			12	SS	90		172							
14.0	Silty Sand to Sandy Silt With Gravel Very Dense													
169.9			13	SS	151		170							
18.8	End of Borehole													
NOTE: This Borehole was done prior to construction of existing bridge, therefore soil information above Elev. 185 ± does not apply.														

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 3

METRIC

W P 138-87-03 LOCATION Co-ordinates N 4 847 874.5; E 301 988.0 ORIGINATED BY BK
DIST 6 HWY 400 BOREHOLE TYPE Washboring COMPILED BY BK
DATUM Geodetic DATE 1959 06 18 CHECKED BY MD

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)			
								20 40 60 80 100										
188.7	Ground Level																	
0.0	Clayey Silt (Fill)						188											
187.8																		
0.9																		
	Clayey Silt to Silt With Sand, Trace of Gravel, Occ. Silty Sand Layer		1	TP	18								21.2					
			2	TP	23								20.9					
	Brown Grey Very Stiff to Hard (Glacial Till)		3	TP	29								23.4					
			4	SS	56								24.3					
			5	SS	117								23.8					
			6	TP	42								21.9					
			7	SS	134													
179.2			8	SS	172													
9.5			9	SS	163													
	Sand with Gravel		10	SS	132													
	Silty Sand to Sandy Silt with Fine Gravel Very Dense		11	SS	268													
169.9																		
18.8	End of Borehole																	
<p>NOTE: This Borehole was done prior to construction of existing bridge, therefore soil information above Elev. 185± does not apply</p>																		

+3, x5: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 4

METRIC

W P 138-87-03 LOCATION Co-ords N 4 847 853.5; E 301 993.0 ORIGINATED BY BK
 DIST 6 HWY 400 BOREHOLE TYPE Washboring COMPILED BY BK
 DATUM Geodetic DATE 1959 06 18 CHECKED BY MD

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
188.8	Ground Level																
0.0	Clayey Silt																
187.8	(Fill)																
1.0			1	SS	21											21.5	
			2	TP	29											22.1	
			3	TP	42											22.1	
			4	SS	110											24.9	
			5	SS	76											22.3	
181.1	Clayey Silt to Silt With Sand, Trace of Gravel, Occ. Silty Sand Layer Very Stiff to Hard (Glacial Till)		6	SS	54											22.6	
7.7			7	SS	126												
			8	SS	80												
			9	SS	169												
			10	SS	141												
			11	SS	148												
			12	SS	149												
170.0																	
18.8	End of Borehole																
	NOTE: This borehole was done prior to construction of existing bridge, therefore soil information above Elev. 185± does not apply																

OFFICE REPORT ON SOIL EXPLORATION

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 5										METRIC					
W P 138-87-03		LOCATION Co-Ords N 4 847 874.0; E 301 932.0				ORIGINATED BY KM									
DIST 6 HWY 400		BOREHOLE TYPE Hollow Stem Augers				COMPILED BY KM									
DATUM Geodetic		DATE 81 02 10				CHECKED BY									
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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40						60
186.3	Ground Level						186								
0.0	Clayey Silt to Silt Some to <u>Brown</u> Trace of Sand <u>Grey</u> Trace of Gravel Occ. Silty Sand Layers Hard (Glacial Till)		1	SS	70	*									
			2	SS	100/	28 cm									
			3	SS	100/	20 cm									
			4	SS	49										
			5	SS	97										
			6	SS	59										
180.1	Sandy Silt Very Dense		7	SS	100/	20 cm	180								
6.2			8	SS	100/	20 cm									
178.2	End of Borehole * W.L. Not Established													2 40 50 8	
8.1															

RECORD OF BOREHOLE No 6

METRIC

W P 138-87-03 LOCATION Co-ords N 4 847 862.0; E 301 942.0 ORIGINATED BY KM
 DIST 6 HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY KM
 DATUM Geodetic DATE 81 02 10 CHECKED BY _____

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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						SHEAR STRENGTH	WATER CONTENT (%)
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE							
186.8	Ground Level														
0.0	Clayey Silt to Silt		1	SS	13		186								
	Some to Trace of Sand		2	SS	35										
			3	SS	100/	18 cm	184								
	Brown Grey		4	SS	100/	18 cm									
	Trace of Gravel		5	SS	100/	18 cm									
	Occ. Silty Sand Layers		6	SS	84		182								
	Very Stiff to Hard (Glacial Till)														
180.7			7	SS	100/	10 cm	180								
6.1	Sandy Silt														
	Trace of Gravel														
178.7	Very Dense		8	SS	100/	28 cm									
8.1	End of Borehole												1 29 65 5		

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 8

METRIC

W P 138-87-03 LOCATION Co-ords N 4 847 833.0; E 301 954.5 ORIGINATED BY KM
 DIST 6 HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY KM
 DATUM Geodetic DATE 81 02 11 CHECKED BY _____

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
192.1	Ground Level												
0.0	Clayey Silt Some Sand Trace of Gravel Firm to Very Stiff (Fill)		1	SS	7		192						
			2	SS	7		190						
			3	SS	28								
			4	SS	17								
188.6			5	SS	32		188						
3.5	Clayey Silt to Silt Some Sand Occ. Silty Sand Layers Hard (Glacial Till)		6	SS	32								
			7	SS	47								
			8	SS	56		186						
184.0			9	SS	100/25 cm								
8.1	End of Borehole												
	* W.L. Not Established												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 2-1

METRIC

W P 138-87-03 LOCATION Co-ords N 4 847 893.0; E 301 981.0 ORIGINATED BY KZ
DIST 6 HWY 400 BOREHOLE TYPE Hollow Stem Auger & Cone Test COMPILED BY KZ
DATUM Geodetic DATE 1987 12 14 CHECKED BY TCK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L		
193.0	Ground Level												
0.0	Sand with Gravel (Fill)		1	SS	10		192						
190.5			2	SS	7		190						
2.5	Clayey Silt With Sand Trace of Gravel (Fill)		3	SS	20		188						
			4	SS	20		186						
185.5			5	SS	18		184						9 33 42 16
7.5			6	SS	24		182						3 33 52 12
	Brown Grey		7	SS	105		180						
	Clayey Silt to Silt With Some Sand Trace of Gravel Occ. Silty Sand Layers Very Stiff to Hard (Glacial Till)		8	SS	86	25 cm	178						
			9	SS	90	15 cm	176						
			10	SS	100	15 cm							
			11	SS	85								2 19 44 35
	Silty Sand		12	SS	88								9 42 38 11
176.8			13	SS	75	15 cm							
16.2	Sandy Silt, Trace Of Gravel and Clay		14	SS	60	15 cm							
174.4	Very Dense		15	SS	60	12 cm							6 39 50 5
18.6	End of Borehole												

OFFICE REPORT ON SOIL EXPLORATION

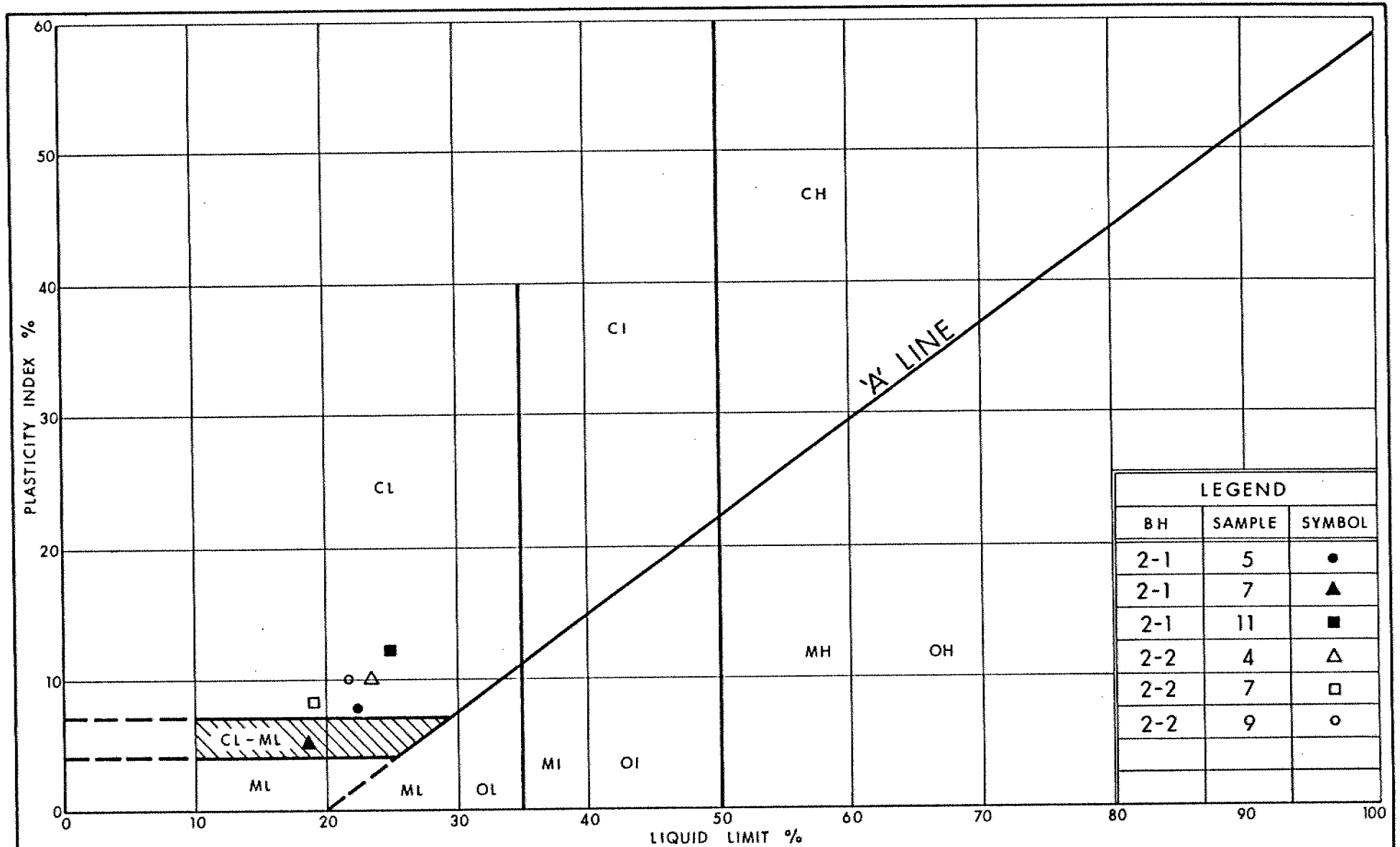
RECORD OF BOREHOLE No 2-2

METRIC

W P 138-87-03 LOCATION Co-ords N 4 847 882.0; E 301 941.5 ORIGINATED BY KZ
 DIST 6 HWY 400 BOREHOLE TYPE Hollow Stem Auger & Cone Test COMPILED BY KZ
 DATUM Geodetic DATE 1987 12 17 CHECKED BY TCK

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	W _p	W					
192.7 0.0	Ground Level														
186.0 6.7	Clayey Silt with Sand Trace of Gravel (Fill)		1	SS	9		192								
			2	SS	8		190								
			3	SS	26		188								
			4	SS	21		186							3 35 41 21	
181.4 11.3	Clayey Silt to Silt With some Sand Trace of Gravel Brown Grey Occ. Silty Sand Layer Very Stiff to Hard (Glacial Till)		5	SS	25		186								
			6	SS	30		184							2 25 57 16	
			7	SS	107		184								
			8	SS	73		182							1 15 64 20	
			9	SS	76		182								
			10	SS	94		180							9 26 48 17	
175.7 17.0	Sandy Silt, Some to Trace of Clay and Gravel Very Dense		11	SS	114/	25 cm	180								
			12	SS	89		178								
			13	SS	116/	25 cm	178								
			14	SS	100/	13 cm	176								
175.7 17.0	End of Borehole		15	SS	135/	23 cm	176							0 11 85 4	

OFFICE REPORT ON SOIL EXPLORATION



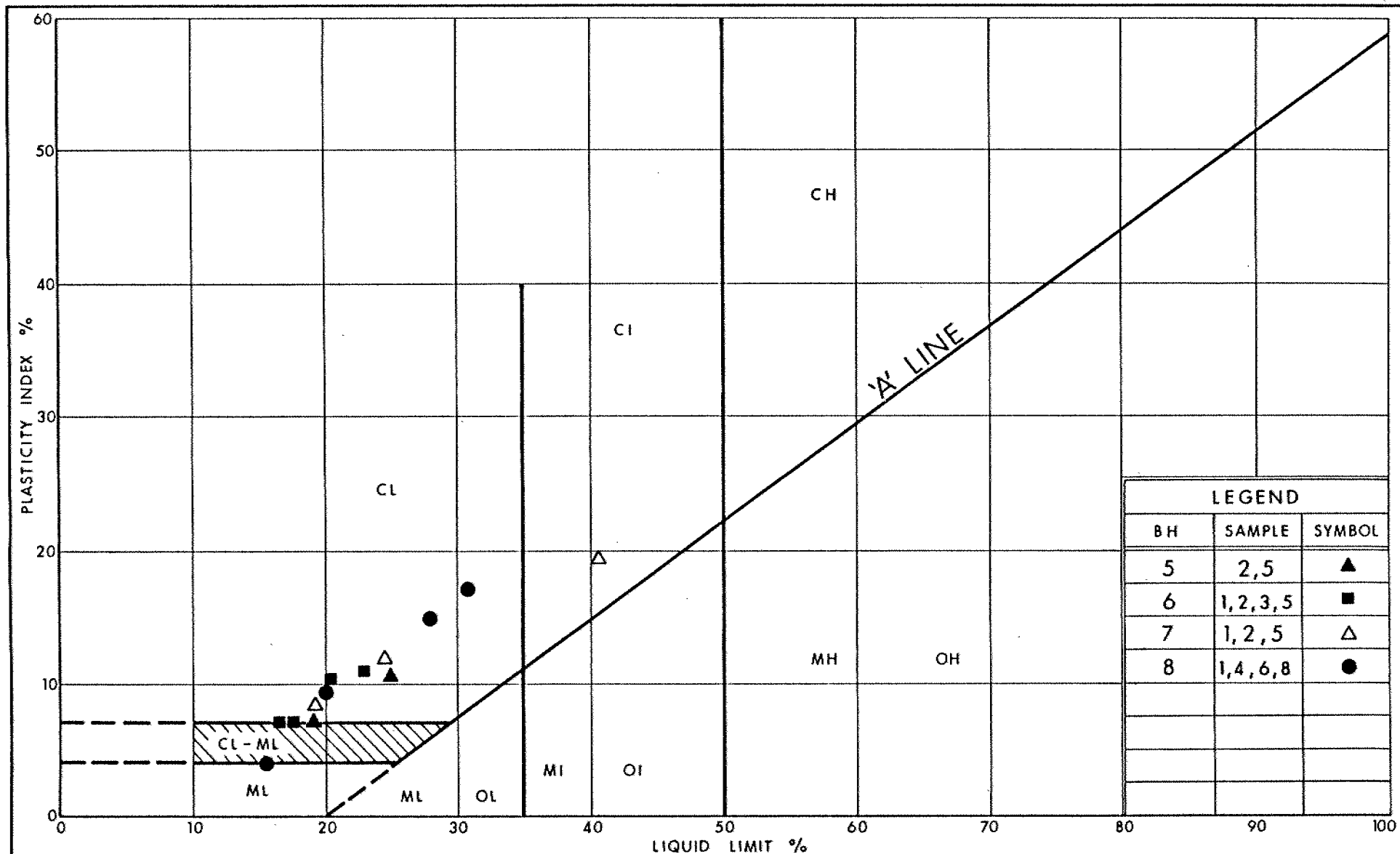
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Ontario

PLASTICITY CHART CLAYEY SILT TO SILT

FIG No 1

W P 138-87-03



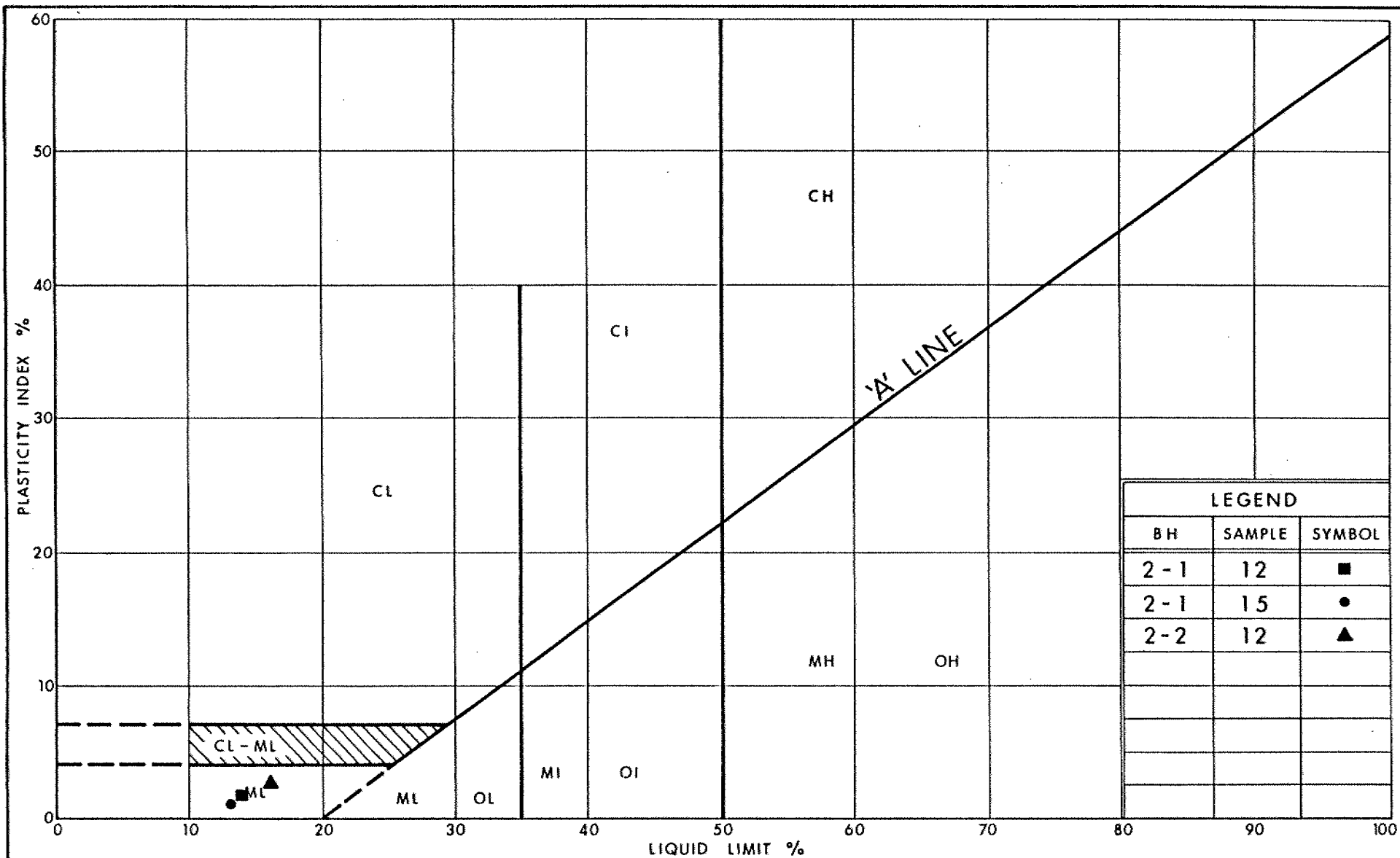
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Transportation

Ontario

PLASTICITY CHART CLAYEY SILT TO SILT

FIG No 2

W P 138-87-03



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Transportation

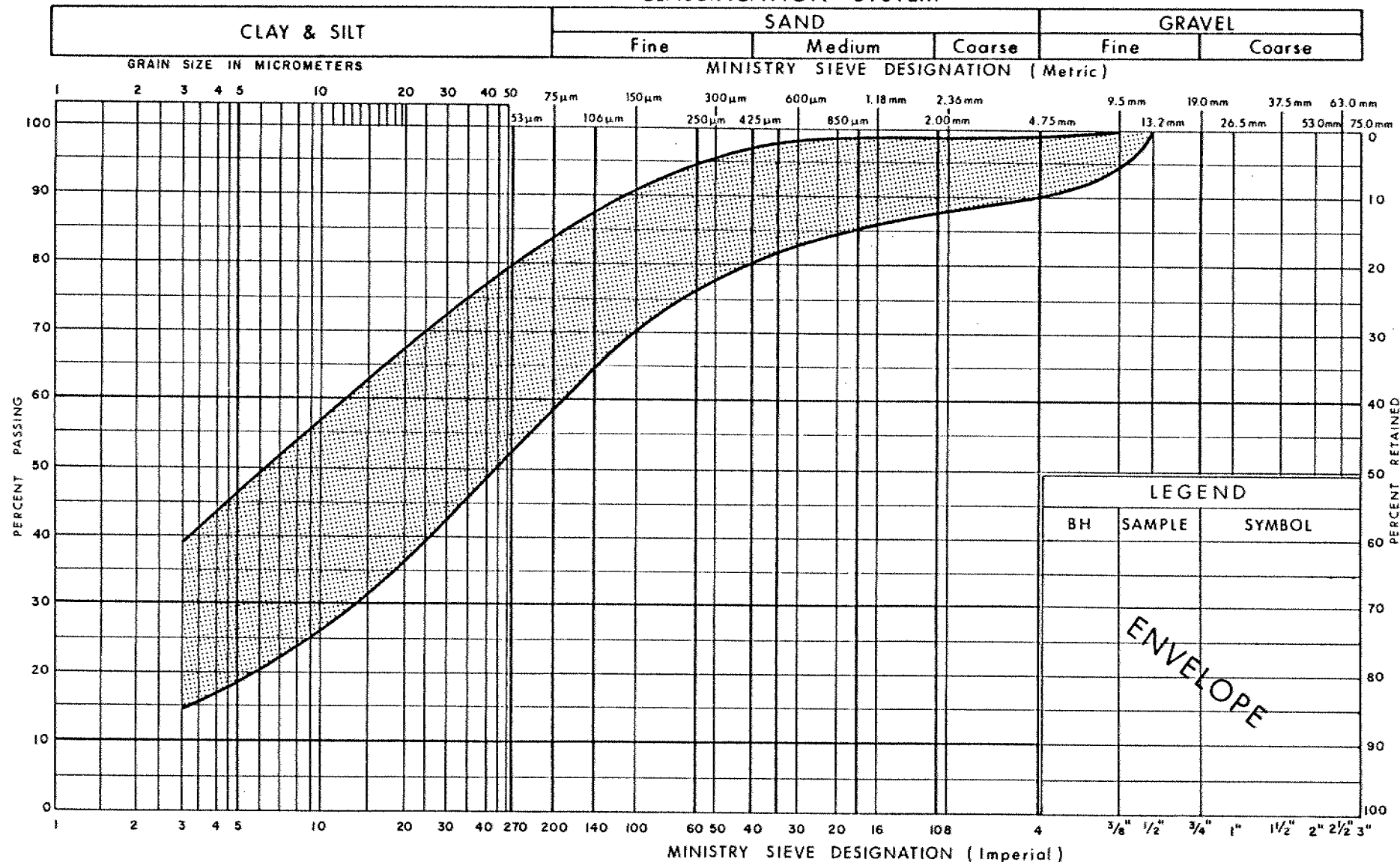
Ontario

PLASTICITY CHART SANDY SILT TO SILTY SAND

FIG No 3

W P 138-87-03

UNIFIED SOIL CLASSIFICATION SYSTEM



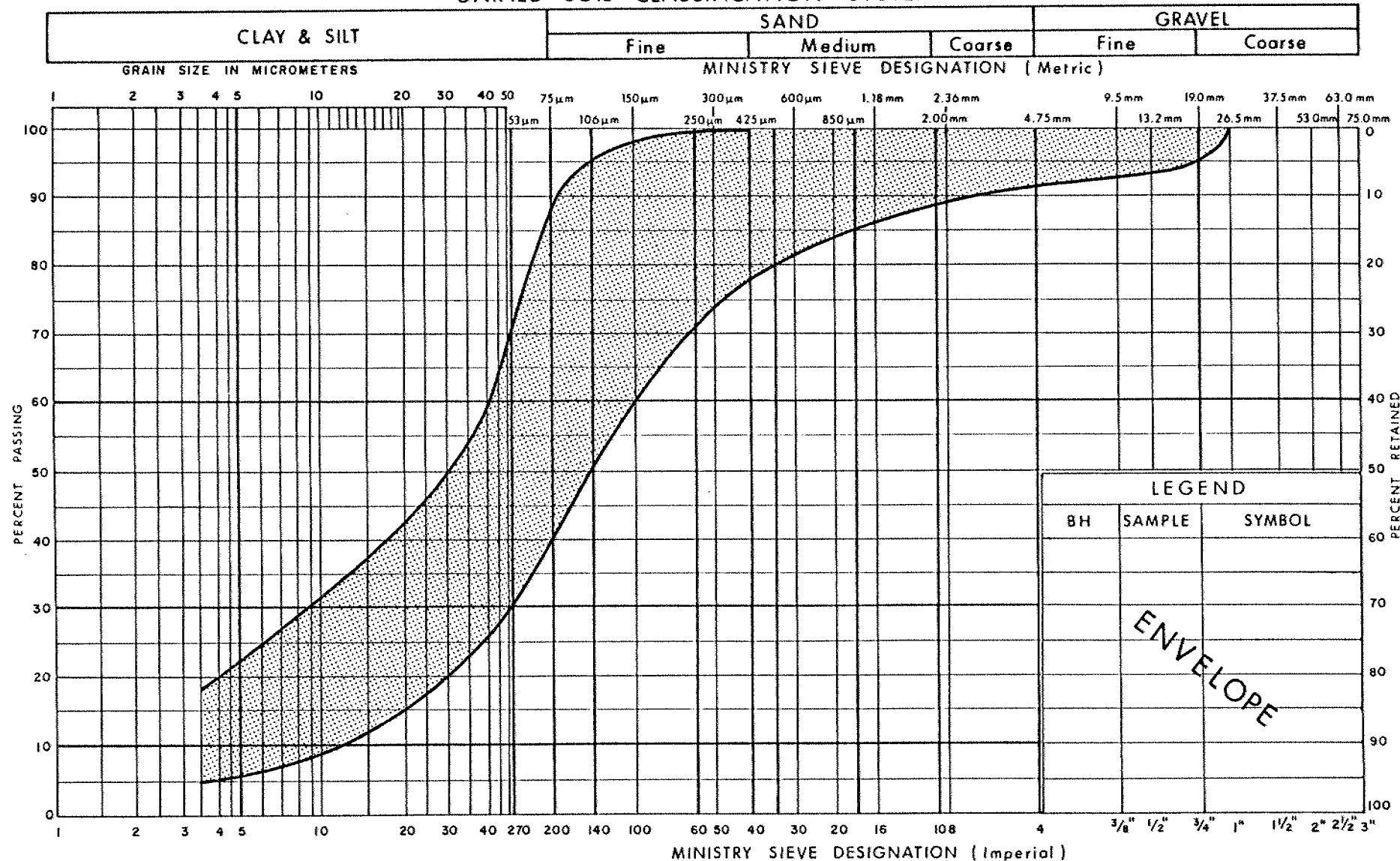
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Transportation

GRAIN SIZE DISTRIBUTION CLAYEY SILT TO SILT

FIG No 4

W P 138-87-03

UNIFIED SOIL CLASSIFICATION SYSTEM



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Transportation

GRAIN SIZE DISTRIBUTION
SANDY SILT TO SILTY SAND

FIG No 5

W P 138-87-03

FOUNDATION INVESTIGATION REPORT
For
Extension of Rigid Frame Structure
Hwy. 400 and CNR Overhead
Bridge #5
W.P. 138-87-06, Site #37-269
Hwy. 400, District 6, Toronto

INTRODUCTION

This report summarizes the results obtained from a Foundation Investigation carried out at the aforementioned site. The existing rigid frame structure will be extended (5.51 m) on either end to facilitate the widening of Hwy. 400 over the C.N.R. New retaining walls will also be required.

SITE DESCRIPTION AND GEOLOGY

The site is located immediately adjacent to the existing C.N.R. Overhead at Hwy. 400 approximately 1 kilometre north of Steeles Avenue in the town of Vaughan.

The terrain surrounding the site is generally flat and partly occupied by the C.N.R. that travels east-west beneath Hwy. 400. Side slopes adjacent to the tracks illustrate the excavation cut required in advancing the CN railway. A single level industrial building exists approximately 1 km northwest of the site. At present, Hwy. 400 is an 8 lane paved roadway.

Geologically, the site is located in the physiographic region known as the Peel Plain. It consists of a bevelled till plain with a gently undulating rolling surface and limited relief. The till plain was deposited by the advance and retreat of the Wisconsin ice sheet during the Pleistocene epoch (over 5000 years ago).

FIELD INVESTIGATION

Difficulty in obtaining access to the CNR-owned area of the site resulted in the field work being divided into two segments. The initial segment involved advancing four sampled boreholes accompanied by dynamic cone penetration tests

outside the CNR right-of-way between 88 01 15 to 88 01 21. The subsequent segment was implemented within the CNR right-of-way between 88 03 24 - 88 03 28 and consisted of four sampled boreholes accompanied by dynamic cone penetration tests.

Continuous flight hollow stem and solid stem auger equipment was used to advance the boreholes with subsoil samples retrieved by a split spoon sampler in accordance with the Standard Penetration Test (ASTM D1586). Washboring techniques were required upon encountering a sandy silt-sand layer at an approximate elevation of 182.0 m at the retaining wall locations. The samples were identified in the field and then transported to the laboratory for applicable testing on selected samples.

Water levels were obtained in the open boreholes until approximate stabilized levels were observed.

Survey information related to location and elevation of boreholes was provided by Central Region Surveys and Plans.

LABORATORY ANALYSES

To identify the behaviour, gradation and property of the soil, laboratory analyses consisted of:

- 1) Atterberg Limit tests/grain size analyses
- 2) Unit weight determination
- 3) Natural moisture content determination

SUBSURFACE CONDITIONS

In general, reasonably competent and uniform subsurface conditions were encountered across the site. Fill material consisting of approximately 3.0 m of well-graded sand overlying an additional 3.0 m thick mixture of clayey silt, sand and gravel was used for the approaches to the existing rigid frame structure.

The native surficial deposit was explored to a maximum thickness of 12.6 m and consists of clayey silt, some sand and a trace of gravel (glacial till) interbedded with a layer of silt-sandy silt of lacustrine origin.

The boundaries between the various soil types, in-situ and laboratory test results, as well as stabilized ground water levels, are shown on the attached Record of Borehole Sheets. A plan of the site illustrating the locations and elevations of the boreholes and subsoil stratigraphical sections are provided on Dwg. 1388706-A.*

A detailed description of the subsurface conditions encountered is given below.

Fill Material (Mixture of Clayey Silt, Sand and Gravel)

The fill material used for the existing approaches to the rigid frame structure consists of a well-graded, compact sand, trace of gravel extending to a depth of approximately 3.0 metres (road base and subbase) overlying a mixture of clayey silt, with/some sand and a trace of gravel that extends a further 3.0 metres before the natural surficial deposit is confronted. Grain size distribution curves for the lower mixture of fill material are illustrated in Figure 1.

Atterberg Limits were also obtained and the results are plotted in Figure 2. The results reveal that the fill is cohesive and of low plasticity. 'N' values indicate a low state of compaction.

Clayey Silt, some sand, trace gravel (Glacial till)

The predominant deposit encountered across the site consists of a clayey silt, some sand and a trace gravel (glacial till) interbedded with a confined stratum of silt-sandy silt of lacustrine origin. Occasional thin seams of non-cohesive silt are also present within the main cohesive clayey silt matrix. A band of organic inclusions was sampled in the upper 0.5 metres of the deposit.

The main component of the deposit is a clayey silt (CL) with random zones of less cohesive plastic silt (CL-ML). In general, the deposit is considered

* DWG NO 2 OF THE CONTRACT DWG'S

cohesive. A grain size distribution envelope for the material as determined by mechanical analyses is given in Figure 3. Atterberg Limits were also obtained to evaluate the behaviour of the fine grained portion of the material and the results are plotted in Figure 4. A summary of the indices of the basic cohesive material matrix is provided in Table 1 below. Unit weights are also included.

Table 1

	<u>Range</u>	<u>Avg.</u>
Natural Moisture Content (w) %	6.5-22.5	11.6
Liquid Limit (w _L) %	13-33.5	21.2
Plastic Limit (w _p) %	9-17.5	13.7
Unit Weight (kN/m ³)	20.2-23.7	22.1

It is evident from the results, the deposit is primarily of low plasticity. In general, lower moisture contents were observed beneath the confined cohesionless silt-sandy silt layer. In addition, the silt content within the till deposit increases beneath the interbedded silt-sandy silt layer and consequently the soil becomes less cohesive and at places the material is only slightly plastic.

Although cobbles and boulders were not encountered during the investigation, they are a characteristic component of these types of deposits and consequently can be assumed to exist in this deposit.

The consistency of the cohesive deposit as indicated by 'N' values of the Standard Penetration Test varies from stiff to hard. Generally, the deposit may be considered to be hard.

A significant layer of silt-sandy silt interbedded with sand seams exists at elevations ranging from elevation 180.6 m to 182.7 m within the predominant till deposit. This layer is a lacustrine deposit and is generally very dense with occasional seams of compact sand. Grain size distribution curves illustrating the gradation of the deposit is provided in Figure 5. This cohesionless layer is water bearing and the fact the the material backed up in the hollow stem augers during drilling indicates that the stratum is perhaps under subartesian head.

GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water level in the open boreholes. Measurements revealed stabilized levels at an elevation ranging from 186.1 metres to 186.0 metres. These levels correspond to depths within 2 metres of the native surficial deposit.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of T. Sangiuliano, Foundation Engineer, utilizing equipment owned and operated by Master Soil Drilling, Toronto. This report was written by T. Sangiuliano and reviewed by Mr. M.S. Devata, Chief Foundation Engineer (East).



D. Dundas
D. Dundas, P. Eng.
Sr. Foundation Engineer

M. Devata
M. Devata, P. Eng.
Chief Foundation Engineer

APPENDIX

RECORD OF BOREHOLE No 1										METRIC			
W P 138-87-06		LOCATION Co-ords. N 4 848 310.9; E 301 877.5		ORIGINATED BY TS									
DIST 6 HWY 400		BOREHOLE TYPE Hollow Stem Augers, Washbore & Cone Test		COMPILED BY TS									
DATUM Geodetic		DATE 88 01 15		CHECKED BY									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT Wp	NATURAL MOISTURE CONTENT W	LIQUID LIMIT Wl	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
194.1	Asphalt Surface												
0.0	Sand Brown, Compact		1	SS	10		194	Augered					
191.0			2	SS	4		192						
3.1	Mixture of Clayey Silt, Sand and Gravel, Trace Organics, Soft (Fill)		3	SS	4		190					20.3	0 26 52 22
189.0	With Organics		4	SS	11		188						
6.1	Stiff to V. Stiff Hard		5	SS	25		186					23.2	2 28 55 15
	Clayey Silt Some Sand, Trace Gravel, Brown (Glacial Till) Random Zones of Silt		6	SS	21		184						
182.7			7	SS	58		182						
11.4	Sandy Silt V. Dense Occ. Sand Seams		8	SS	75		180						
	Compact		9	SS	55		178						
178.9	(Lacustrine)		10	SS	120		176						
15.2			11	SS	78								
			12	SS	65								
175.4			13	SS	10								
			14	SS	94								
			15	SS	93								
			16	SS	100								
18.7	End of Borehole												
<p>* NOTE Soil backed up in augers at 11.5 m. Advance by washboring inside augers.</p>													

RECORD OF BOREHOLE No 2

METRIC

W P 138-87-06 LOCATION Co-ords. N 4 848 267.0; E 301 885.0 ORIGINATED BY TS
DIST 6 HWY 400 BOREHOLE TYPE Hollow Stem Auger, Washbore & Cone Test COMPILED BY TS
DATUM Geodetic DATE 88 01 19 CHECKED BY

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						
194.2	Asphalt Surface													GR SA SI CL
0.0	Sand Brown Compact		1	SS	15		194	Mugered						
190.7			2	SS	7		192							
3.5	Mixture of Clayey Silt Sand and Gravel Soft (Fill)		3	SS	4		190						21.7	
188.1			4	SS	18		188							6 22 39 33
6.1	With Organ. Clayey Silt Some Sand Trace Gravel		5	SS	19		186						19.3	1 23 41 35
	Stiff to V. Stiff Hard		6	SS	14									
	Brown Grey		7	SS	21		184						23.2	10 17 56 17
	(Glacial Till) Random Zones of Silt		8	SS	22									
182.0			9	SS	110		182							2 31 62 5
12.2	Sandy Silt V. Dense (Lacustrine)		10	SS	72		180							
178.7			11	SS	120									
15.5			12	SS	110/	23 cm	178							
			13	SS	100/	15 cm								
			14	SS	100/	23 cm	176							
			15	SS	100/	15 cm								
175.5			16	SS	100									
18.7	End of Borehole													
	* NOTE Soil backed up in augers at 12.4 m. Advance by washboring inside augers.													

RECORD OF BOREHOLE No 3										METRIC			
W P 138-87-06		LOCATION		Co-ords. N 4 848 321.0; E 301 905.0		ORIGINATED BY TS							
DIST 6 HWY 400		BOREHOLE TYPE		Hollow Stem Auger, Washbore & Cone Test		COMPILED BY TS							
DATUM Geodetic		DATE		88 01 19		CHECKED BY							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
194.1	Asphalt Surface												
0.0	Sand Brown Compact						194						
							192						
189.5			1	SS	10		190						
4.6	Mix. of Clayey Silt Sand and Gravel V. Stiff (Fill)		2	SS	30		188						
188.0			3	SS	10		186						
6.1	Stiff to V. Stiff Hard		4	SS	20		184						
	Clayey Silt Some Sand, Trace Gravel (Glacial Till) Random Zones of Silt		5	SS	45		182						
			6	SS	100		180						
			7	SS	100		178						
			8	SS	100	15 cm							
			9	SS	80	15 cm							
182.7			10	SS	100	15 cm							
11.4	Sand With Gravel V. Dense (Lacustrine)												
			11	SS	100	15 cm							
178.9			12	SS	100								
15.2													
177.0			13	SS	60	15 cm							
17.1	End of Borehole												
<p>* NOTE</p> <p>Soil backed up in augers at 11.5 m, advance by washboring inside augers.</p>													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 4

METRIC

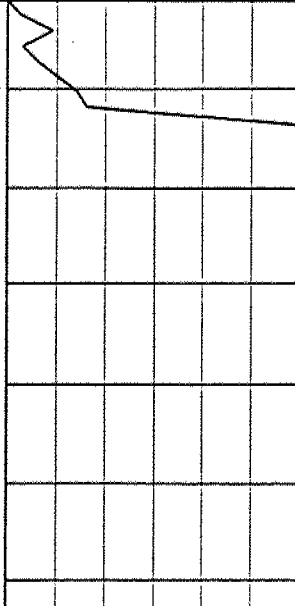
W P 138-87-06 LOCATION Co-ords. N 4 848 274.0; E 301 913.0 ORIGINATED BY TS
 DIST 6 HWY 400 BOREHOLE TYPE Hollow Stem Auger, Washbore & Cone Test COMPILED BY TS
 DATUM Geodetic DATE 88 01 21 CHECKED BY _____

OFFICE REPORT ON SOIL EXPLORATION

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40						60	80	100	WATER CONTENT (%)	10	20	30
								SHEAR STRENGTH kPa							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
194.2	Asphalt Surface																				
0.0	Sand Brown Compact						194	Augered													
190.7	Mix. of Clayey Silt Sand and Gravel (Fill)		1	SS	6		192														
3.5							190														
			2	SS	4																
188.1							188														
6.1	With Organics		3	SS	25																
	Clayey Silt Some/with Sand Trace Gravel		4	SS	28																
			5	SS	19																
	Brown Grey V.Stiff Hard		6	SS	26		186														
			7	SS	100																
	(Glacial Till)		8	SS	55		184														
	Random Zones of		9	SS	120																
	Silt		10	SS	110																
182.0			11	SS	120		182														
12.2	Sandy Silt Very Dense																				
	Occ. Sand Seams (Lacustrine)		12	SS	15		180														
179.0			13	SS	100	15 cm															
15.2							178														
			14	SS	100																
							176														
175.5			15	SS	100																
18.7	End of Borehole																				
	<u>*NOTE</u> Soil backed up in augers at 12.4 m. Advance by washboring inside augers.																				

RECORD OF BOREHOLE No 5										METRIC				
W P 138-87-06		LOCATION Co-ords. N 4 848 296.9; E 301 874.1				ORIGINATED BY TS								
DIST 6 HWY 400		BOREHOLE TYPE Cone Test, Solid Stem Auger				COMPILED BY TS								
DATUM Geodetic		DATE 88 03 25				CHECKED BY								
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			20 40 60 80 100	WATER CONTENT (%)					
185.0	Ground Surface													
0.0	Clayey Silt Stiff Some Sand Hard Trace Gravel		1	SS	15		184							
	(Glacial Till) Brown Random Zones Grey		2	SS	33									
			3	SS	80									
181.5	of Silt		4	SS	41		182							
3.5			5	SS	119									
	Silt Dense to V. Dense Occ. Sand Seams		6	SS	53		180							
	(Lacustrine)		7	SS	24									
178.4			8	SS	111		178							
6.6			9	SS	100	13 cm								
			10	SS	100	13 cm	176							
			11	SS	110		174							
172.4			12	SS	118									
12.6	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 6										METRIC			
W P 138-87-06		LOCATION Co-ords. N 4 848 280.0; E 301 877.0				ORIGINATED BY TS							
DIST 6 HWY 400		BOREHOLE TYPE Cone Test, Solid Stem Auger				COMPILED BY TS							
DATUM Geodetic		DATE 88 03 22				CHECKED BY							
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100	W _p W W _L	WATER CONTENT (%) 10 20 30			
185.8	Ground Surface												
0.0	Clayey Silt Some Sand Stiff to V. Stiff Hard	Brown Grey	1	SS	10	15 cm		20.2	2 18 59 21				
	Trace Gravel (Glacial Till)		2	SS	28								
	Random Zones of Silt		3	SS	100								
181.2			4	SS	120								
4.6	Silt, Some Sand Trace Gravel, V. Dense (Lacustrine)		5	SS	100								
			6	SS	120								
179.7			7	SS	100								
6.1			8	SS	100								
			9	SS	110								
			10	SS	100								
			11	SS	100								
173.3			12	SS	100					15 cm			
12.5	End of Borehole												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 7

METRIC

W P 138-87-06 LOCATION Co-ords. N 4 848 307.0; E 301 912.3 ORIGINATED BY TS
DIST 6 HWY 400 BOREHOLE TYPE Cone Test, Solid Stem Auger COMPILED BY TS
DATUM Geodetic DATE 88 03 25 CHECKED BY

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100				
185.6	Ground Surface															
0.0	Clayey Silt Some Sand Trace Gravel Grey, Hard (Glacial Till)	Brown Grey	1	SS	42										22.1	5 20 55 20
			2	SS	85											
182.6			3	SS	100											
3.0	Silt, V. Dense Occ. Sand Seams (Lacustrine)		4	SS	70											
			5	SS	80	15 cm										11 30 49 10
180.6			6	SS	65											
5.0			7	SS	120											
			8	SS	120											
			9	SS	100	12 cm										4 40 52 4
			10	SS	110											
			11	SS	100	15 cm										
173.3			12	SS	60	7 cm										
12.3	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 8

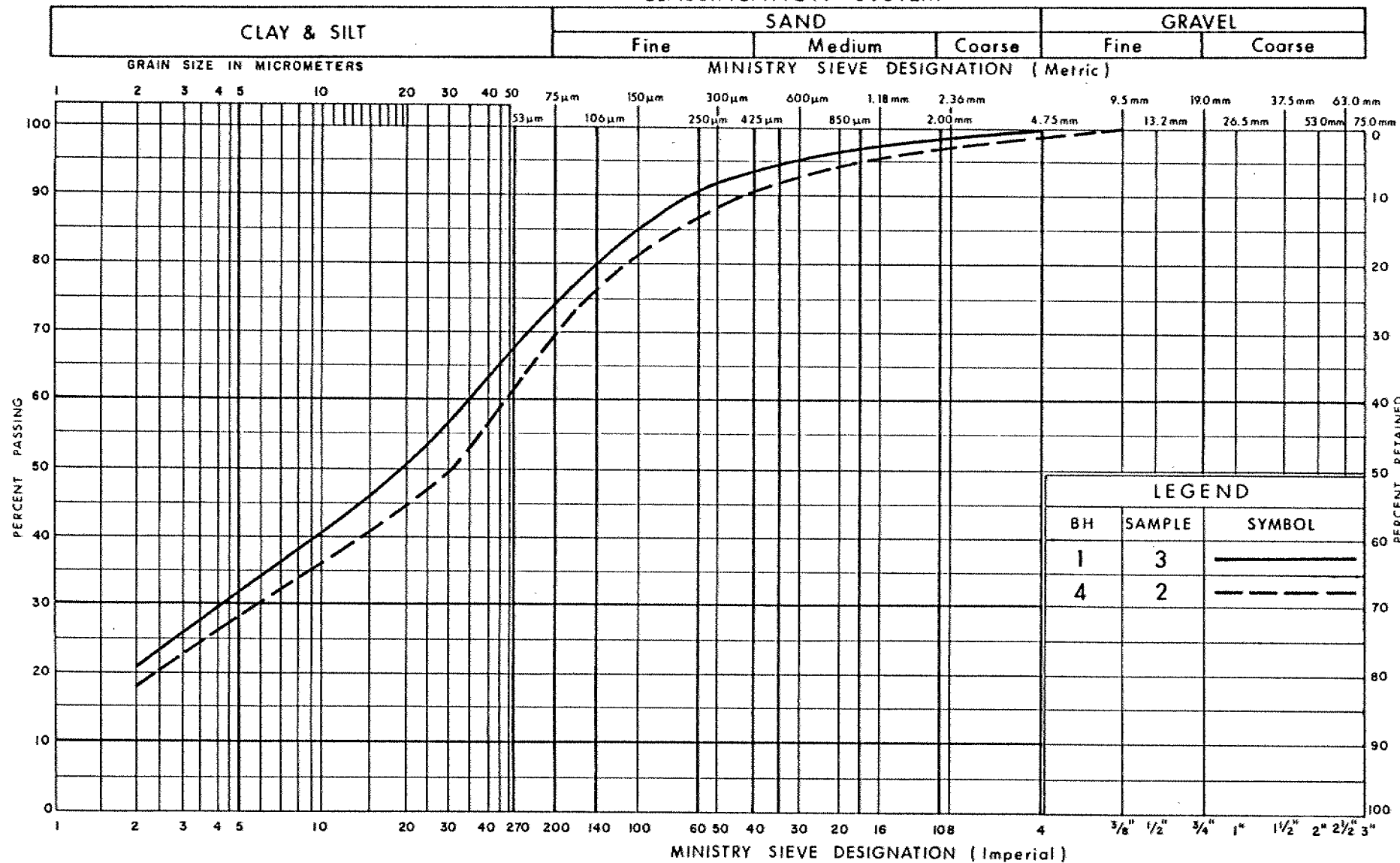
METRIC

W P 138-87-06 LOCATION Co-ords. N 4 848 291.0; E 301 915.0 ORIGINATED BY TS
 DIST 6 HWY 400 BOREHOLE TYPE Cone Test, Solid Stem Auger COMPILED BY TS
 DATUM Geodetic DATE 88 03 28 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT Y kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	W _p	W	W _L		
								SHEAR STRENGTH kPo ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	WATER CONTENT (%) 10 20 30				
185.9	Ground Surface												
0.0	Clayey Silt Some Sand Trace Gravel		1	SS	12		184				22.9	1 29 54 16	
	Stiff Hard		2	SS	71		182						
	Brown Grey		3	SS	100		180						
	(Glacial Till)		4	SS	52		178						
	Random Zones of		5	SS	37		176						
	Silt		6	SS	120		174						
180.6			7	SS	48								
5.3	Silt, Dense (Lacustrine)		8	SS	91								
179.8			9	SS	100	15 cm	178						
6.1			10	SS	80	15 cm	176						
			11	SS	100								
173.3			12	SS	100								
12.6	End of Borehole												

OFFICE REPORT ON SOIL EXPLORATION

UNIFIED SOIL CLASSIFICATION SYSTEM

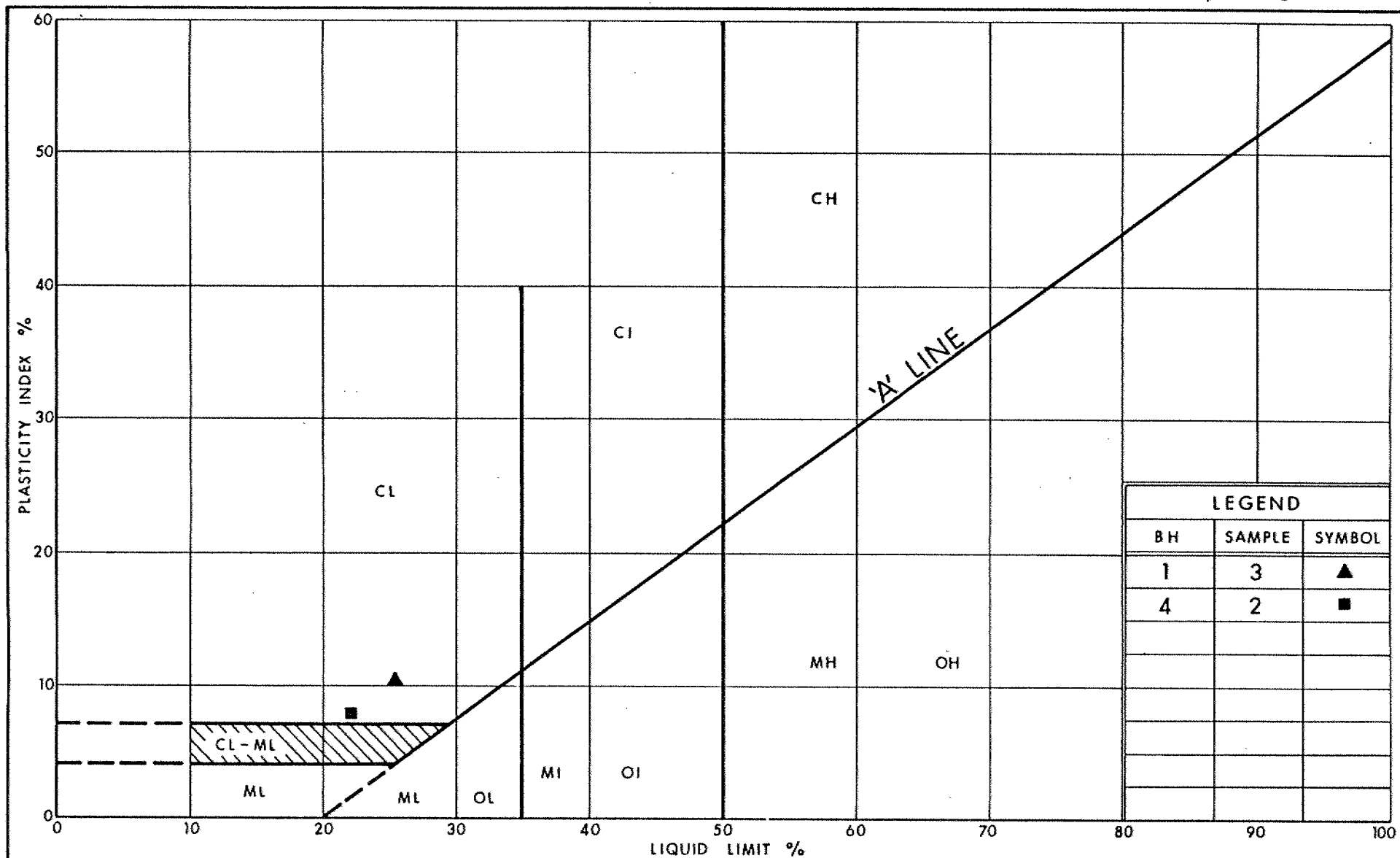


Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
MIXTURE OF
CLAYEY SILT, SAND & GRAVEL (Fill)

FIG No 1

W P 138-87-06



Ministry of
Transportation

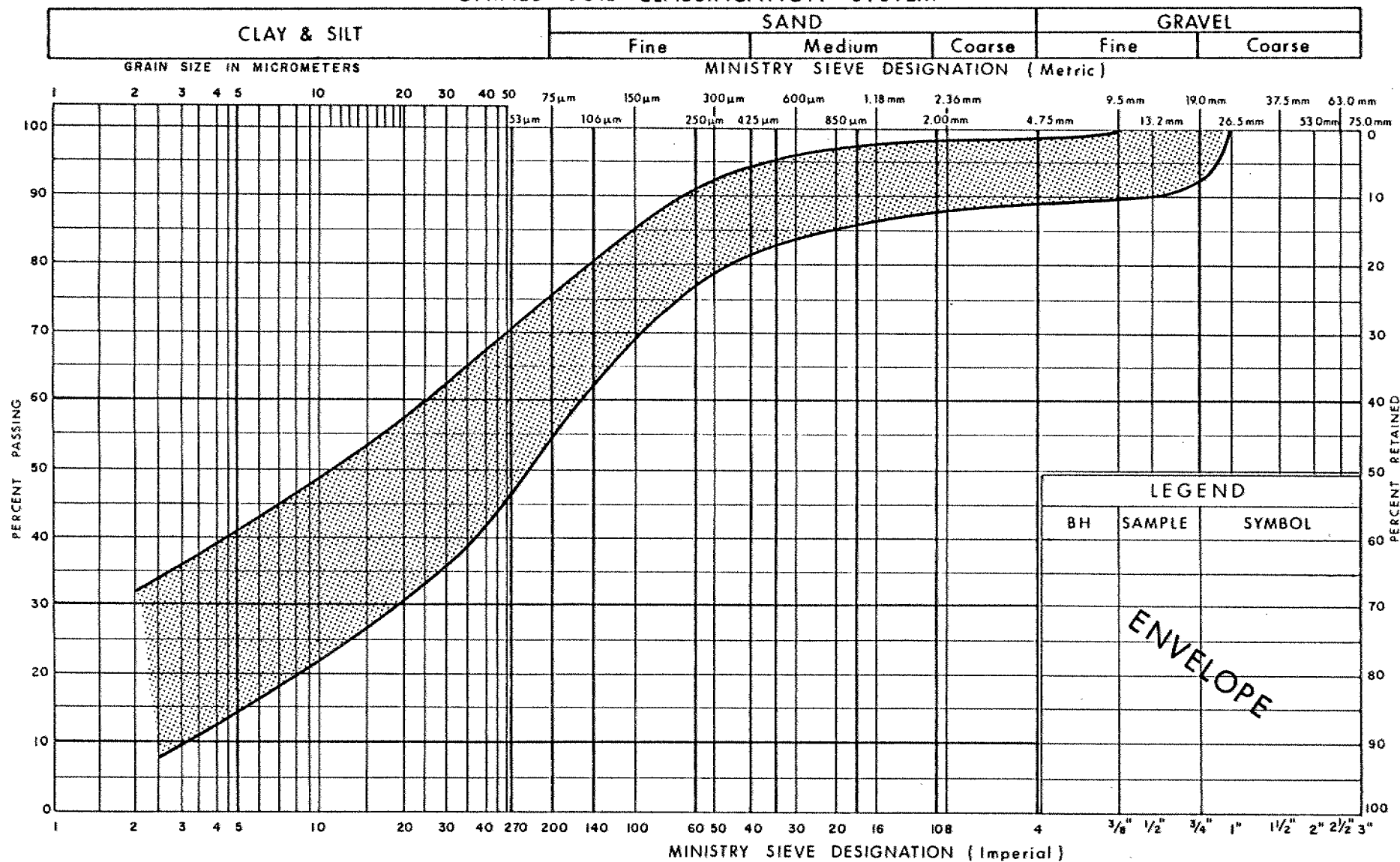
Ontario

PLASTICITY CHART MIXTURE OF CLAYEY SILT, SAND & GRAVEL (Fill)

FIG No 2

WP 138-87-06

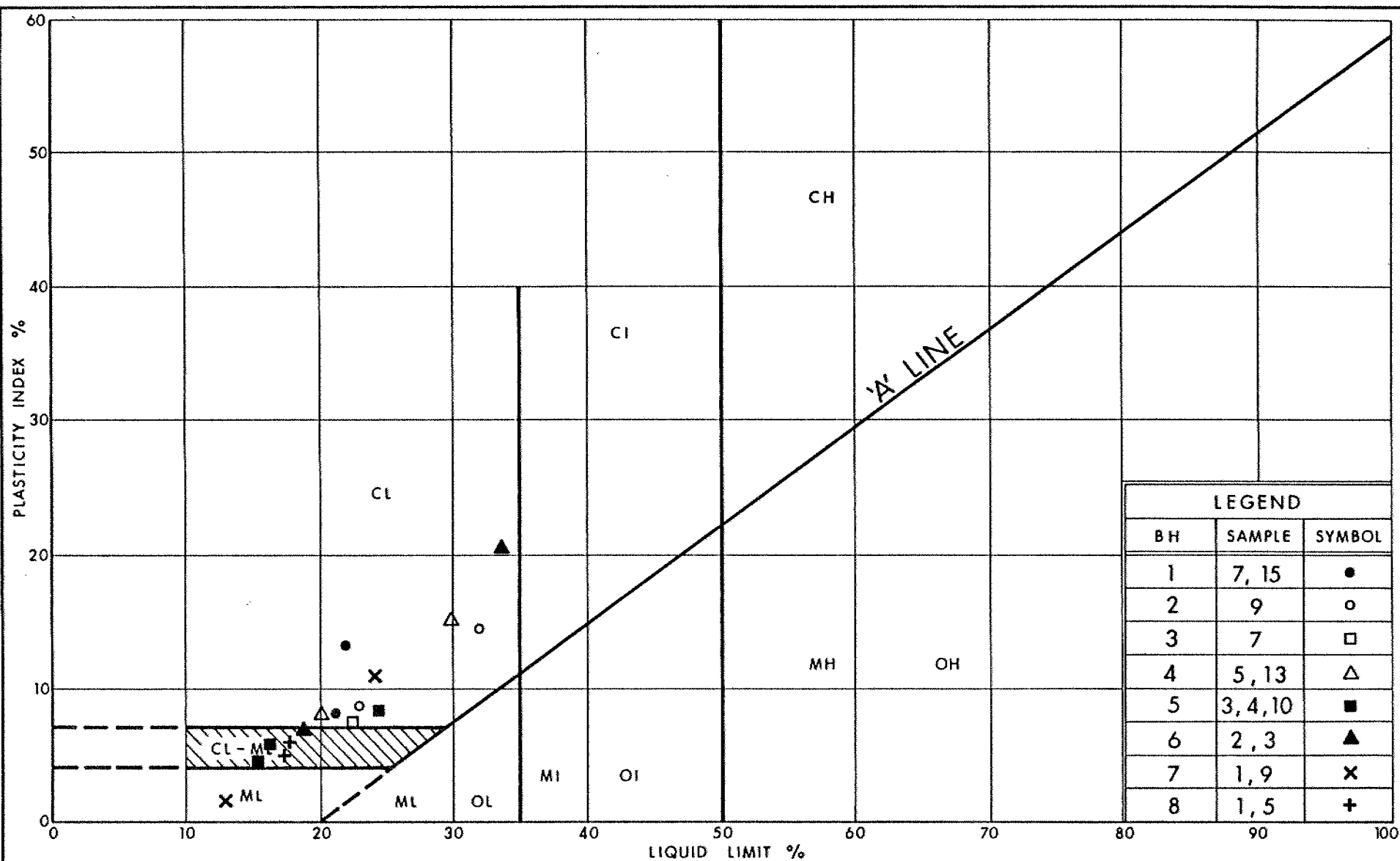
UNIFIED SOIL CLASSIFICATION SYSTEM


 Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
 CLAYEY SILT, WITH/SOME SAND, TRACE GRAVEL
 (Glacial Till)

FIG No 3

W P 138-87-06



Ontario

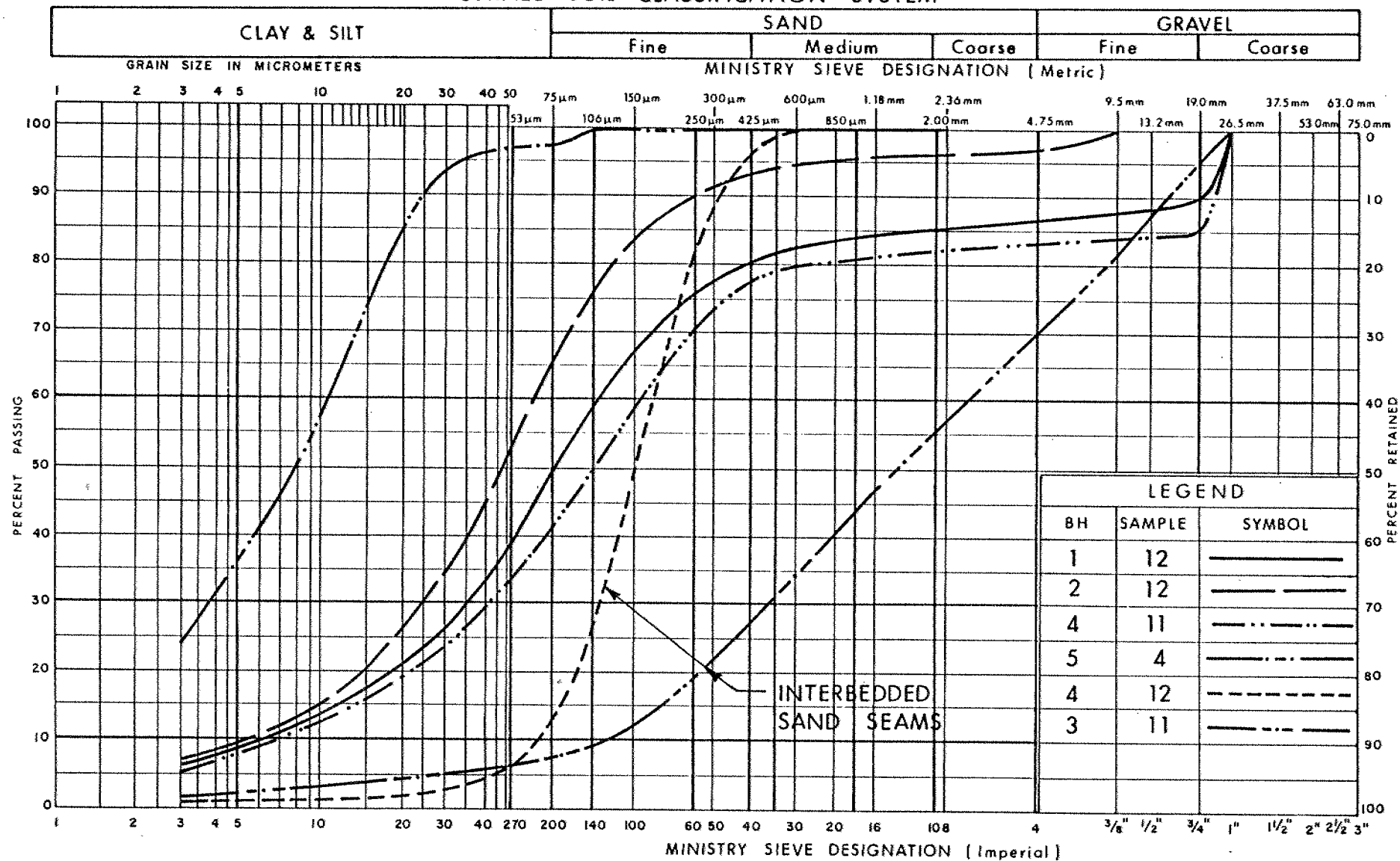
Ministry of
Transportation

PLASTICITY CHART CLAYEY SILT, WITH/SOME SAND, TRACE GRAVEL (Glacial Till)

FIG No 4

W P 138-87-06

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SILT - SANDY SILT
WITH INTERBEDDED SAND SEAMS

FIG No 5

W P 138-87-06

FOUNDATION INVESTIGATION REPORT
for
BRIDGE #20
HWY. 407 EW - 400 S.B.L.
W.P. 138-87-09, Site 37-1183
District #6, Toronto

INTRODUCTION

This report summarizes the foundation investigation for the proposed new bridge that will carry ramp 407 E.W. over existing ramp Steeles Ave. E.W. to highway 400 S.B..

The field work was carried out from 88 01 11 to 88 01 23, utilizing a continuous flight auger machine, equipped with 82 mm I.D. hollow stem augers and B casing. The investigation consisted of 5 sampled boreholes and 5 dynamic cone penetration tests. The boreholes ranged from 14.2 m to 30.9 m in depth.

Groundwater levels were measured in open holes at each borehole location.

Site Description

The site is located in the northwest quadrant of the existing Steeles Ave/Highway 400 interchange. It is bordered to the north by the CNR railway line, to the east by Highway 400, to the south by Steeles Ave. and by private property to the west.

Both Highway 400 and Ramp Steeles Ave. E-W 400 S are built on 4 to 7 metre high fills.

Subsurface Conditions

The subsurface conditions generally consist of 6 m of Sand (Fill) which represents the existing ramp EW 400 S. Underlying the fill material is a deposit of Clayey Silt (Glacial Till) averaging 12 m in thickness. The glacial till overlies a thick deposit of sand. The limits of the sand layer were not established during the investigation.

The boundaries of the subsoil types, laboratory test results, and groundwater levels are shown on the Record of Borehole log sheets contained in the Appendix. The locations and elevations of the boreholes, along with the stratigraphical profile are shown on Drawing 1388709-A.*

The various soils encountered at this site are described as follows:

Sand (Fill)

The existing ramp E-W 400 S is composed mainly of non-cohesive granular fill material. The top layer consists of granular road bed material, while the remaining consists primarily of sand.

The thickness of the fill material corresponds to the height of the ramp above original ground, ranging between 5.5 to 7.0 m.

From the 'N' values of the Standard Penetration Test, the material can be described as moderately to well compacted.

Clayey Silt and Sand Mixture (Fill)

The side slopes of ramp EW 400 S are covered with a mixture of non-cohesive sand and cohesive clayey silt (BH #5 and #6). The sand is the same material as described above.

The presence of the clayey silt can be attributed to the fact that the side slopes were covered with native material to protect the embankment from erosion.

The thickness of this layer is approximately 2.5 m, and based on the 'N' values from the SPT test, can be described as in a very loose to loose state.

* DWG NO 2 OF THE CONTRACT DWG'S

Heterogeneous Mixture Clayey Silt (Glacial Till)

This material was encountered in all boreholes and represents the original ground level for the area.

It is a deposit of cohesive, low plasticity material, ranging in thickness from 12.2 to 13.8 m. Silt and sand seams occur intermittently, and cobbles were encountered in borehole #4.

Based on 'N' values the material can be classified as firm to hard.

Typical laboratory values are as follows:

	<u>Range (%)</u>	<u>Average (%)</u>
Water Content (w)	8.5-21.0	14.8
Liquid Limit (W_L)	13.0-34.5	22.4
Plastic Limit (W_p)	10.0-22.0	13.9

Figure 1 illustrates a typical plasticity chart for this material based on representative samples from the entire site.

Figure 2 represents a typical grain size distribution for the material, based on representative samples obtained from the site.

Sand Some Silt

This deposit underlies the clayey silt till in all areas. The vertical extent of the deposit was not established during the investigation.

It can generally be categorized as silty sand with occasional sandy silt pockets (Borehole #3).

This layer is non-cohesive and water bearing. Boiling conditions were noted as the sand layer was penetrated in boreholes #3, 4, and 6.

The material is in a loose to very dense state based on SPT 'N' values.

Groundwater

The groundwater levels were measured in open boreholes, with elevations ranging from 185.4 m to 187.9 m.

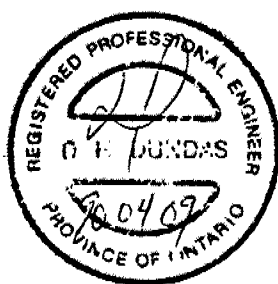
Due to the short period of time that boreholes #3 and 6 were open, their water levels are not considered to be stabilized.

Boreholes number 1, 4 and 5 offer a more representative stabilized ground water level. From the information available, the groundwater level is estimated to be at elevation 186.0 m.

MISCELLANEOUS

The fieldwork was carried out under the supervision of R. Otway, Foundation Engineer, using equipment rented from Malones Soil Samples.

The report was written by R. Otway and reviewed by M. Devata, Chief Foundations Engineer (East).



D. Dundas
D. Dundas, P. Eng.
Sr. Foundation Engineer

M. Devata
M. Devata, P. Eng.
Chief Foundation Engineer

APPENDIX

RECORD OF BOREHOLE No 1

METRIC

W P 138-87-09 LOCATION Co-ords. N 4 848 144.9 E 301 867.2 ORIGINATED BY RO
DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Auger - Cone Test COMPILED BY RO
DATUM Geodetic DATE 88 01 18 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
186.7	Ground Surface												
0.0	Sand		1	SS	40		186						
185.2	Some Silt Dense (Fill)		2	SS	14		184						2 30 42 26
1.5			3	SS	16								
			4	SS	18								
	Brown Grey		5	SS	13								
			6	SS	32								
	Heterogeneous Mixture		7	SS	48								3 22 53 22
	Clayey Silt		8	SS	46								
	Some Sand												
	Trace Gravel		9	SS	43								
	Occ. Boulders												
	Occ. Silt Seams		10	SS	39								
	Stiff to Hard												
	(Glacial Till)		11	SS	119/23 cm		176						5 25 64 6
			12	SS	109		174						
172.5			13	SS	100								
14.2	End of Borehole												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 3

METRIC

W P 138-87-09 LOCATION Co-ords. N 4 848 182.0 E 301 860.0 ORIGINATED BY RO
DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Auger - Cone Test COMPILED BY RO
DATUM Geodetic DATE 88 01 11 CHECKED BY DD

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100	WATER CONTENT (%)				
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					
191.6	Top of Asphalt							10 20 30				GR SA SI CL	
0.0	Sand Some Silt Dense (Fill)		1	SS	42								
			2	SS	46								
			3	SS	43								
			4	SS	33								
184.6	Brown Grey Heterogeneous Mixture Clayey Silt Some Sand Trace Gravel Occ. Boulders Occ. Silt Seams Stiff to Hard (Glacial Till)		5	SS	18							1 29 48 22	
7.0			6	SS	18								
			7	SS	12								
			8	SS	28								
			9	SS	38								
			10	SS	49								
			11	SS	37								
			12	SS	28								
			13	SS	35								
			14	SS	74								
			15	SS	63/15 cm								
			16	SS	90								
171.9	Silt with Sand		17	SS	N/A							0 20 77 3	
19.7													
171.3													
20.3	End of Borehole												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 4

METRIC

W P 138-87-09 LOCATION Co-ords. N 4 848 194.5 E 301 841.3 ORIGINATED BY RO
DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Auger - Cone Test COMPILED BY RO
DATUM Geodetic DATE 88 01 12 CHECKED BY DD

OFFICE REPORT ON SOIL EXPLORATION

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa					
191.3	Top of Asphalt								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					GR SA SI CL
0.0	Granular (Fill)													
190.4														
0.9	Sand Some Silt Occ. Clayey Zones Compact to Dense (Fill)		1	SS	18									
			2	SS	39									
			3	SS	18									
185.8			4	SS	23									
5.5			5	SS	14									2 38 40 20
			6	SS	17									
	Brown Grey		7	SS	8									1 25 50 24
	Heterogeneous Mixture		8	SS	55									
	Cobbles		9	SS	52									
			10	SS	41									0 18 65 17
	Clayey Silt Some Sand Trace Gravel Occ. Boulders Occ. Silt Seams Stiff to Hard (Glacial Till)		11	SS	38									
			12	SS	41									0 19 75 6
			13	SS	100	8 cm								
			14	SS	55	8 cm								
			15	SS	50	10 cm								
			16	SS	50	8 cm								1 14 81 4
172.0			17	SS	7									
19.3			18	SS	89									0 10 87 3
	Sand		19	SS	63									
	Some Silt		20	SS	55	15 cm								
			21	SS	63									
	Loose to Very Dense		22	SS	114									
			23	SS	100	20 cm								
160.4														
30.9	End of Borehole													

+3, x5: Numbers refer to Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 5										METRIC					
W P 138-87-09		LOCATION Co-ords. N 4 848 216.0 E 301 836.0				ORIGINATED BY RO									
DIST 6 HWY 407		BOREHOLE TYPE Hollow Stem Auger - Cone Test				COMPILED BY RO									
DATUM Geodetic		DATE 88 01 18				CHECKED BY DD									
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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						
187.7	Ground Surface														
0.0	Clayey Silt and Sand Mixture Very Loose (Fill)		1	SS	3		186								
185.3			2	SS	11		184								5 34 41 20
2.4			3	SS	15										
			4	SS	17										
			5	SS	9		182								
			6	SS	62										
			7	SS	43		180								
			8	SS	69										
			9	SS	41										3 13 52 32
			10	SS	42		178								
			11	SS	26		176								0 51 46 3
			12	SS	100	15 cm									
			13	SS	100	8 cm	174								5 37 44 14
173.1			14	SS	42		172								
14.6			15	SS	100	18 cm	170								
169.0			16	SS	88										
18.7	End of Borehole														

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 6

METRIC

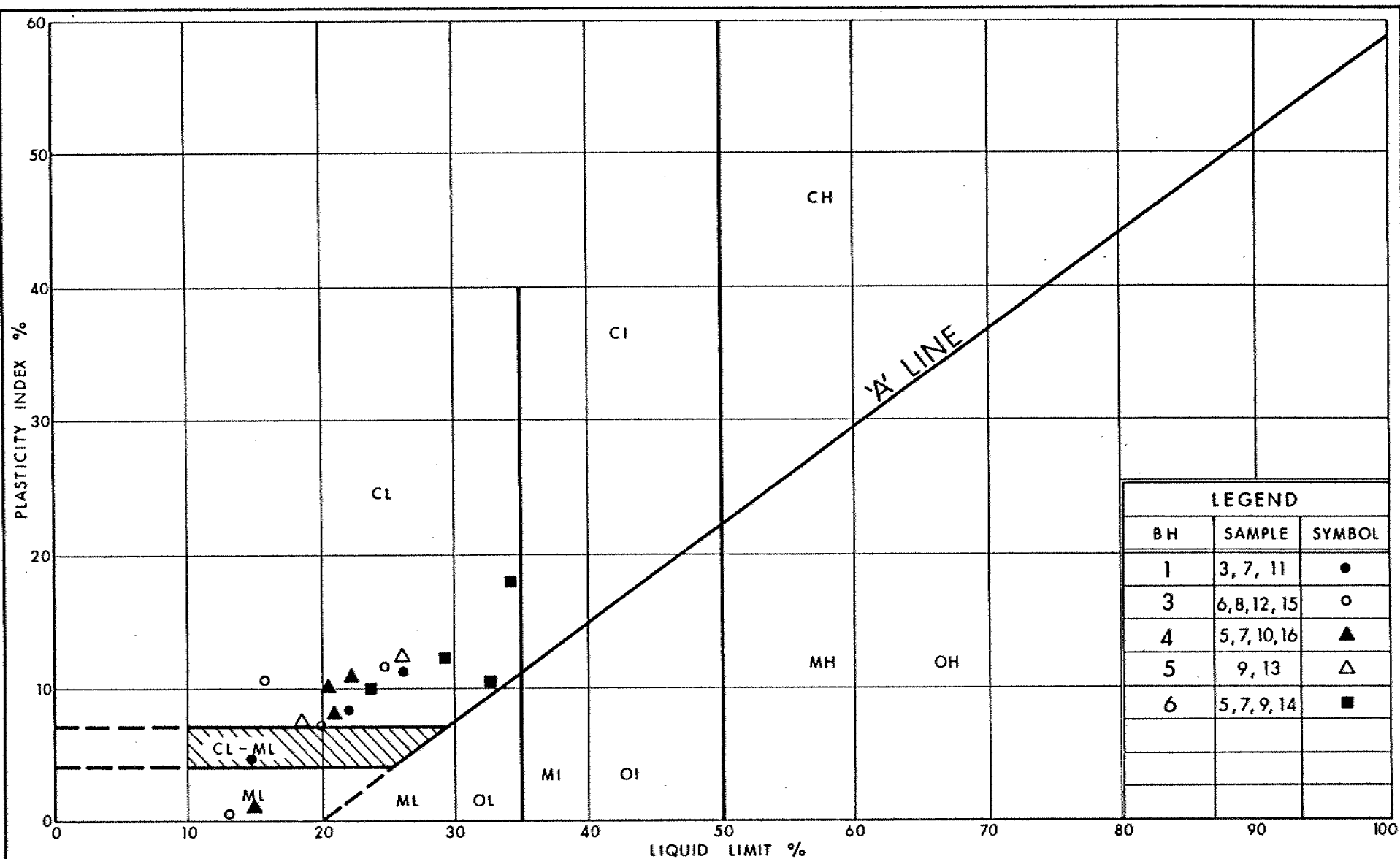
W P 138-87-09 LOCATION Co-ords. N 4 848 203.0 E 301 855.5 ORIGINATED BY RO
 DIST 6 HWY 407 BOREHOLE TYPE Hollow Stem Auger - Cone Test COMPILED BY RO
 DATUM Geodetic DATE 88 01 20 CHECKED BY DD

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			VALUES	20 40 60 80 100					
189.1	Ground Surface												
0.0	Clayey Silt and Sand Mixture Loose (Fill)		1	SS	7								
186.6			2	SS	11								
2.5			3	SS	23								
			4	SS	23								
			5	SS	14								
			6	SS	12								
	Brown Grey Heterogeneous Mix. Clayey Silt		7	SS	29								1 25 43 31
			8	SS	97								2 20 62 16
	Some Sand Trace Gravel Occ. Boulders Occ. Silt Seams Stiff to Hard (Glacial Till)		9	SS	100								7 18 58 17
			10	SS	82								
			11	SS	34								
			12	SS	16								0 11 84 5
	Silt Some Sand Compact		13	SS	100/10 cm								
			14	SS	94								0 1 65 34
172.9			15	SS	9								
16.2			16	SS	53								
	Sand		17	SS	47								
	Some Silt		18	SS	13								
	Loose to Very Dense		19	SS									
			20	SS	83								
			21	SS	87								
			22	SS	56								
161.2			23	SS	59								
27.9	End of Borehole												
	* Water Level Not Established												

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION



Ministry of
Transportation

Ontario

PLASTICITY CHART
HET MIXTURE OF
CLAYEY SILT, SOME SAND TRACE GRAVEL (Glacial Till)

FIG No 1

W P 138-87-09



FOUNDATION INVESTIGATION REPORT
For
Ramp Hwy. 400 N to Hwy. 407 E W
Hwy. 400 South Bound Collector (Structure #13)
W.P. 142-87-03 Site 37-1177
District 6, Toronto

INTRODUCTION

This report summarizes the information obtained from the foundation investigation carried out for the above-noted project during the period of December 21, 1987 to January 11, 1988.

Seven boreholes (BH #13-1 to #13-7) were advanced and sampled as part of this project by means of hollow stem augers and washboring techniques. These boreholes extended to depths between 12.2 and 23.3 metres below the ground surface.

This report contains factual information pertaining to the foundations for the structure and associated retaining walls as shown on Drawing No. 1428703-A*.

SITE DESCRIPTION AND GEOLOGY

The site is located at the proposed Hwy. 407/400 interchange, 200 metres west of Hwy. 400 and about 0.5 km south of Hwy. 7. Topography is mainly flat. The land to the east contains Hwy. 400 and the construction site of the Hwy. 400 & 7 interchange. To the west is a Drive-In Theatre and service station.

The site is located in the physiographic region known as the "Peel Plain" as described by the physiography of Southern Ontario (Chapman and Putnam, 1984). This region is characterized by a level to gently undulating topography sloping gradually towards the south. The underlying soil consists of a hard layer of glacial till. The till deposits are interbedded with some continuous lacustrine layers and frequent random discontinuous silt to sand pockets.

* DWG NO 2 OF THE CONTRACT DWG'S

Bedrock was not encountered during the investigation but is reported to be composed of shale and limestone laminations and located below elevation 120± metres. Land use is mainly for agricultural purposes.

SUBSURFACE CONDITIONS

The record of Borehole Sheets in the Appendix illustrate the subsurface conditions at the borehole locations. The locations and elevations of the boreholes, along with stratigraphical profiles based on the borehole data are shown on Drawing No. 1428703-A. *

The subsoil conditions encountered across the site were generally uniform consisting primarily of the following generalized deposits, in sequence, from the surface down:

<u>Elevations (m)</u>		
<u>From</u>	<u>To</u>	<u>Material</u>
193.2	190.3	Clayey Silt (Glacial Till)
190.3	175.4	Clayey silt to silt with random silt and sand pockets (Glacial Till with lacustrine Interbeds)
175.4	Undetermined	Silty Clay with thin silt seams (Lacustrine)

* DWG NO 2 OF THE CONTRACT DWG'S

Properties of the glacial till deposits are variable across the site, and the boundaries between the soil strata are transitional.

More detailed description of the subsoil deposits will be presented.

Clayey Silt (Glacial Till)

A layer of clayey silt with some sand and a trace of gravel extends from the ground surface to depths between 2.9 and 4.4 metres. The material changes in colour from brown to grey at two borehole locations (at BH #13-1, elevation 190.2 metres, at BH #13-6, elevation 188.9 metres).

Typical properties of the material, as determined by laboratory tests of representation samples are summarized as follows:

<u>Properties</u>	<u>Range (%)</u>
Moisture Content (w)	10.0 - 14.0
Liquid Limit (w_L)	18.5 - 23.5
Plastic Limit (w_p)	11.0 - 12.0
Plasticity Index (I_p)	7.5 - 11.0

The Atterberg Limit Test results are illustrated on the Plasticity Chart (Figure 1). From the chart it is evident that the layer can be classified as an inorganic clayey silt (CL).

Grain size distribution tests were carried out on these samples. Figure 3 in the Appendix shows the results in envelope form.

Standard Penetration Test 'N' values between 6 and 85 indicated that the soil can be interpreted as being firm to hard.

Clayey Silt to Silt (Glacial Till)

This deposit has been described as clayey silt to silt, some sand, trace of gravel, with random silt and sand pockets and occasional boulders. The main component of this deposit varies randomly from non-plastic silt (ML), to slightly plastic silt (CL-ML), to clayey silt (CL). Within this deposit there are frequent random discontinuous pockets of silts and sands. A semi-continuous layer of lacustrine silt to sand, varying in thickness was encountered at the various elevations, at all boreholes.

At the Bridge #13 site, this material was encountered at all borehole locations where it extended for thickness varying from over 9.3 to 14.9 metres.

Typical properties of the basic cohesive material matrix, as determined by laboratory tests of representative samples are summarized as follows:

<u>Properties</u>	<u>Range (%)</u>
Moisture Content (w)	8.0 - 19.0
Liquid Limit (w_L)	15.0 - 31.5
Plastic Limit (w_p)	10.5 - 15.0
Plasticity Index (I_p)	4.0 - 18.5

Figure 1 illustrates the plasticity chart for this material, based on representatives samples.

Figure 3 illustrates an envelope of typical grain size distribution for this material.

Based on 'N' values which ranged from 9 to over 100 blows/0.3 m for this structure, the denseness of this deposit can be described as loose to very dense for the non-cohesive zones while the consistency is stiff to hard for the cohesive zones. Generally, the deposit may be considered to be dense to very dense for the non-cohesive component or hard for the cohesive component.

Silty Clay (Lacustrine)

This lacustrine deposit has been described as silty clay with thin silt seams. The thickness of this deposit was not fully explored at this site, but it is in excess of 5.5 metres. Within this deposit there is occasional thin layer of silt, generally up to 1.5 m thick at Borehole #13-2.

Atterberg Limit Test results are summarized below:

<u>Properties</u>	<u>Range (%)</u>
Moisture Content (w)	13.5 - 24.0
Liquid Limit (w_L)	35.0 - 50.0
Plastic Limit (w_p)	15.0 - 17.0
Plasticity Index (I_p)	19.0 - 33.0

The Atterberg Limit Test results are illustrated on the plasticity chart (Figure 2).

Grain size distribution tests were carried out on these samples. Figure 4 shows that the results in envelope form. Standard Penetration Test 'N' values between 52 and over 100 blows/0.3 m indicate that this deposit is in hard state.

The results of all field and laboratory testing, along with a summary of the subsoil conditions encountered in each borehole are shown on the Record of Borehole Sheets (See Appendix). Stratigraphical profiles are shown on Drawing No. 1428703-A.* Also shown on this drawing is a generalized plan of the site area showing the locations of the boreholes with respect to the relevant structure.

* DWG NO 2 OF THE CONTRACT DWG'S

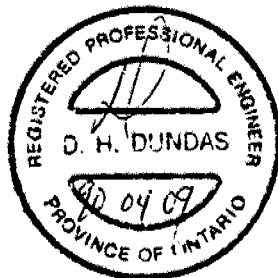
GROUNDWATER CONDITIONS

Groundwater conditions were observed through the measurements of water levels in the open boreholes. Groundwater level in the borings was found to range between elevation 190.9 metres at BH #13-7 and elevation 192.7 metres at BH #13-1 about 1.0 metres below the existing ground surface.

MISCELLANEOUS

The fieldwork for this investigation was carried out during the period of 87-12-21 to 88-01-11 under the supervision of Ken Zasitko (Technician). The equipment was owned and operated by Master Soil Investigation Toronto.

This report was written by T.C. Kim, Foundation Engineer and reviewed by M. Devata, Chief Foundations Engineer (East).



D. Dundas
D. Dundas, P. Eng.
Sr. Foundation Engineer

M. Devata
M. Devata, P. Eng.
Chief Foundation Engineer

APPENDIX

RECORD OF BOREHOLE No 13-1

METRIC

W P 142-87-03 LOCATION Co-ords. N 4 849 385.2; E 301 629.5 ORIGINATED BY KZ
 DIST 6 HWY 400 BOREHOLE TYPE Hollow Stem Auger & Cone Test COMPILED BY KZ
 DATUM Geodetic DATE 87 12 21 & 22 CHECKED BY TCK

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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	10 20 30					
193.2	Ground Level													
0.0	Clayey Silt Some Sand Trace Gravel Stiff to Hard Brown Grey (Glacial Till)		1	SS	16	88 I 4	192							5 38 38 19
			2	SS	10									
			3	SS	17									
			4	SS	16									
188.8			5	SS	85			120/10 cm						
4.4	Silt V. Dense (Lacustrine)		6	SS	76		188							0 6 74 20
	Clayey Silt to Silt Some Sand Trace Gravel Occ. Sandy Silt Layers Hard (Glacial Till)		7	SS	50									
			8	SS	96		186							2 15 69 14
			9	SS	100									
			10	SS	73		184							
			11	SS	39		182							
	Sand and Silt		12	SS	105	25 cm	180							0 43 56 1
			13	SS	146									
177.7			14	SS	150	25 cm	178							1 20 61 18
15.5	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 13-2

METRIC

W P 142-87-03 LOCATION Co-ords. N 4 849 411.5; E 301 615.0 ORIGINATED BY KZ
DIST 6 HWY 400 BOREHOLE TYPE Hollow Stem Auger, Wash Boring, Cone Test COMPILED BY KZ
DATUM Geodetic DATE 87 12 22, 23 CHECKED BY TCK

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						
193.2	Ground Level													
0.0	Clayey Silt Some Sand Trace Gravel Stiff (Glacial Till)		1	SS	9	88 1.4	192							
			2	SS	11									
190.3			3	SS	12									
2.9	Silt (Compact) (Lacustrine)		4	SS	13		190							
	Grey Clayey Silt to Silt		5	SS	41									
	Some Sand		6	SS	101									
	Trace Gravel		7	SS	108		188							1 22 65 12
	Occ. Silt Layers		8	SS	45									
	Hard (Glacial Till)		9	SS	67		186							
			10	SS	32		184							
			11	SS	38		182							2 24 58 16
			12	SS	66									
			13	SS	44		180							13 9 67 11
	Silt		14	SS	50		178							
			15	SS	127		176							
175.4			16	SS	52		174							
17.8	Silty Clay		17	SS	100	8 cm								0 0 95 5
	Occ. Silt Layers	Silt Trace Clay	18	SS	114		172							
	Hard (Lacustrine)		19	SS	90		170							0 0 44 56
169.9														
23.3	End of Borehole													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 13-3										METRIC		
W P 142-87-03		LOCATION Co-ords. N 4 849 418.6; E 301 627.8				ORIGINATED BY KZ						
DIST 6 HWY 400		BOREHOLE TYPE Hollow Stem Auger, Wash Boring, Cone Test				COMPILED BY KZ						
DATUM Geodetic		DATE 87 12 23 and 88 01 04				CHECKED BY TCK						
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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE			'N' VALUES	20 40 60 80 100					
193.0	Ground Level											
0.0	Clayey Silt Some Sand Trace Gravel Stiff (Glacial Till)	1	SS	13								14 38 33 15
		2	SS	10								
190.1		3	SS	14								
2.9	Silt, Loose (Lacustrine)	4	SS	9								
	Brown Grey	5	SS	38								
	Clayey Silt to Silt	6	SS	52								
	Some Sand	7	SS	56								
	Trace Gravel	8	SS	46								
	Occ. Sandy Silt Layers	9	SS	111								
	Very Stiff to Hard (Glacial Till)	10	SS	54								
		11	SS	35								
	Sand	12	SS	32								
	Some Gravel and Silt	13	SS	24								
177.5		14	SS	100	10 cm							
15.5	End of Borehole											

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 13-4										METRIC		
W P 142-87-03		LOCATION Co-ords. N 4 849 450.5; E 301 609.5		ORIGINATED BY KZ								
DIST 6 HWY 400		BOREHOLE TYPE Hollow Stem Auger & Cone Test		COMPILED BY KZ								
DATUM Geodetic		DATE 88 01 7, 8		CHECKED BY TCK								
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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH.	DESCRIPTION	NUMBER	TYPE			VALUES	20 40 60 80 100					
192.2	Ground Level											
0.0	Clayey Silt Some Sand Trace Gravel Firm to Very Stiff (Glacial Till) Brown Grey	1	SS	16								
		2	SS	13								
		3	SS	16								
188.5		4	SS	7								
3.7	Silt, Dense (lacustrine)	5	SS	35								6 38 41 15
	Clayey Silt to Silt	6	SS	51								
	Some Sand	7	SS	69								
	Trace Gravel	8	SS	39								
	Occ. Sandy Silt Layers	9	SS	24								0 4 79 17
	Very Stiff to Hard (Glacial Till)	10	SS	42								
		11	SS	55								
	Silt	12	SS	37								
	Trace Clay	13	SS	132/23 cm								0 0 99 1
		14	SS	101								0 5 45 50
175.0		15	SS	114/23 cm								
17.2	End of Borehole											

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 13-5

METRIC

W P 142-87-03 LOCATION Co-ords. N 4 849 449.0; E 301 594.5 ORIGINATED BY KZ
DIST 6 HWY 400 BOREHOLE TYPE Hollow Stem Auger & Cone Test COMPILED BY KZ
DATUM Geodetic DATE 88 01 07 CHECKED BY TCK

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20 40 60 80 100		W _p	W	W _L		
192.2 0.0	Ground Level												GR SA SI CL
	Clayey Silt Some Sand Trace Gravel Firm to Very Stiff (Glacial Till)		1	SS	6								
			2	SS	10								
			3	SS	17								
188.5	Brown		4	SS	9								
3.7	Grey Sandy Silt (Lacustrine)		5	SS	82								6 37 48 9
			6	SS	45								
	Clayey Silt to Silt Some Sand Trace Gravel Occ. Sandy Silt Layers Hard (Glacial Till)		7	SS	118	20 cm							1 20 67 12
			8	SS	40								
			9	SS	47								
			10	SS	28								
			11	SS	47								2 32 52 14
			12	SS	35								
	Sand and Gravel		13	SS	74								
177.5													
14.7	Silty Clay Occ. Silt Layers Hard (Lacustrine)		14	SS	111								0 0 61 39
175.0			15	SS	114	25 cm							
17.2	End of Borehole												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 13-6

METRIC

W P 142-87-03 LOCATION Co-ords. N 4 849 483.4; E 301 592.1 ORIGINATED BY KZ
 DIST 6 HWY 400 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY KZ
 DATUM Geodetic DATE 88 01 05 CHECKED BY TCK

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						
192.3	Ground Level													GR SA SI CL
0.0	Clayey Silt Some Sand Trace Gravel Stiff to Very Stiff (Glacial Till)		1	SS	13		192							
			2	SS	13		190							
			3	SS	17									
188.6	Brown Grey		4	SS	12									
3.7	Sand, Compact (Lacustrine)		5	SS	23		188						3 76 18 3	
	Clayey Silt to Silt Some Sand Trace Gravel Occ. Sandy Silt Layers Very Stiff to Hard (Glacial Till)		6	SS	49			120/20 cm						
			7	SS	77		186							
			8	SS	31		184							
			9	SS	20		182						1 29 58 12	
			10	SS	64		180							
	Sand Some Silt		11	SS	87								0 81 17 2	
			12	SS	55		178							
177.7			13	SS	100	10 cm	176							
14.6	Silty Clay Occ. Silt Layers Hard (Lacustrine)		14	SS	129								0 0 40 60	
175.1			15	SS	116									
17.2	End of Borehole													

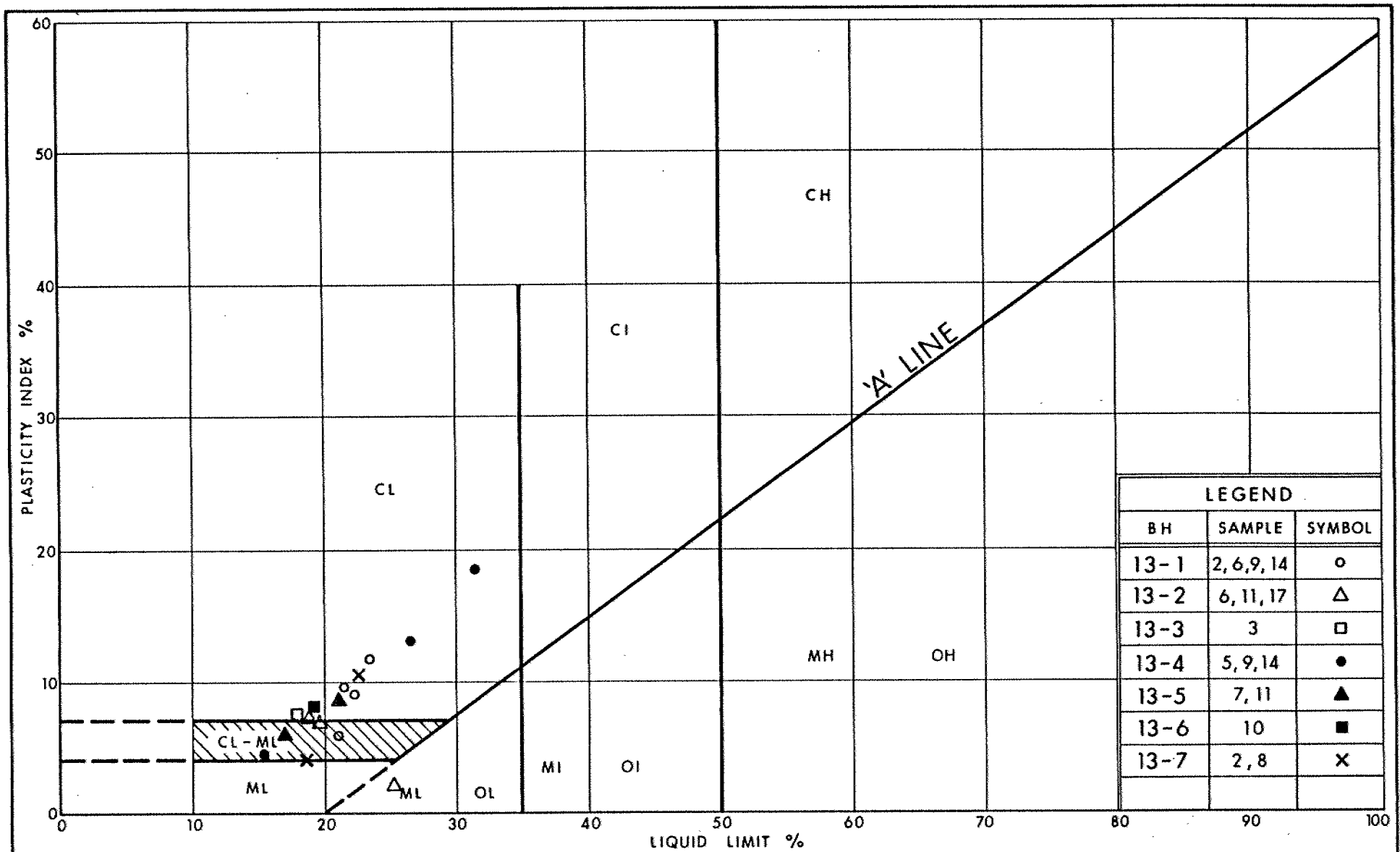
OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 13-7										METRIC				
W. F. 142-87-03		LOCATION		Co-ords. N 4 849 501.5; E 301 584.0				ORIGINATED BY KZ						
DIST 6 HWY 400		BOREHOLE TYPE		Hollow Stem Auger & Cone Test				COMPILED BY KZ						
DATUM Geodetic		DATE		88 01 11				CHECKED BY TCK						
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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					
191.8	Ground Level													
0.0	Clayey Silt Some Sand Trace Gravel Stiff to Very Stiff (Glacial Till)		1	SS	12									3 34 46 17
188.9			2	SS	15									
			3	SS	16									
2.9	Silt, Compact Brown (Lacustrine)		4	SS	12									
	Clayey Silt to Silt Some Sand Trace Gravel		5	SS	43									1 21 66 12
	Occ. Sandy Silt Layers Hard (Glacial Till)		6	SS	31									
			7	SS	39									
	Silt Some Sand and Clay		8	SS	30									2 16 66 16
			9	SS	60									0 16 77 7
179.6														
12.2	End of Borehole Refusal to Auger Due to Apparent Boulders													

OFFICE REPORT ON SOIL EXPLORATION

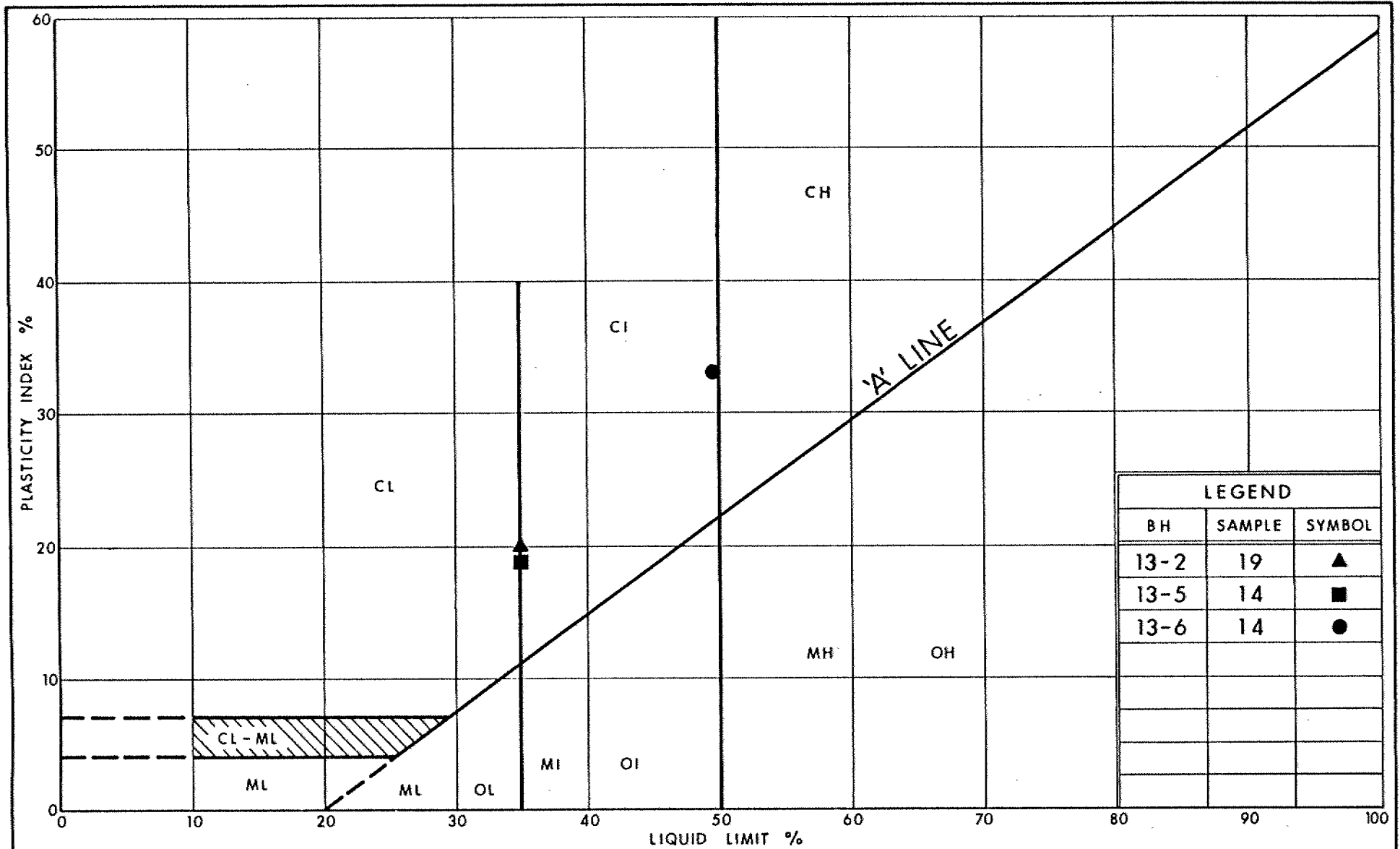


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PLASTICITY CHART CLAYEY SILT TO SILT

FIG No 1

W P 142-87-03



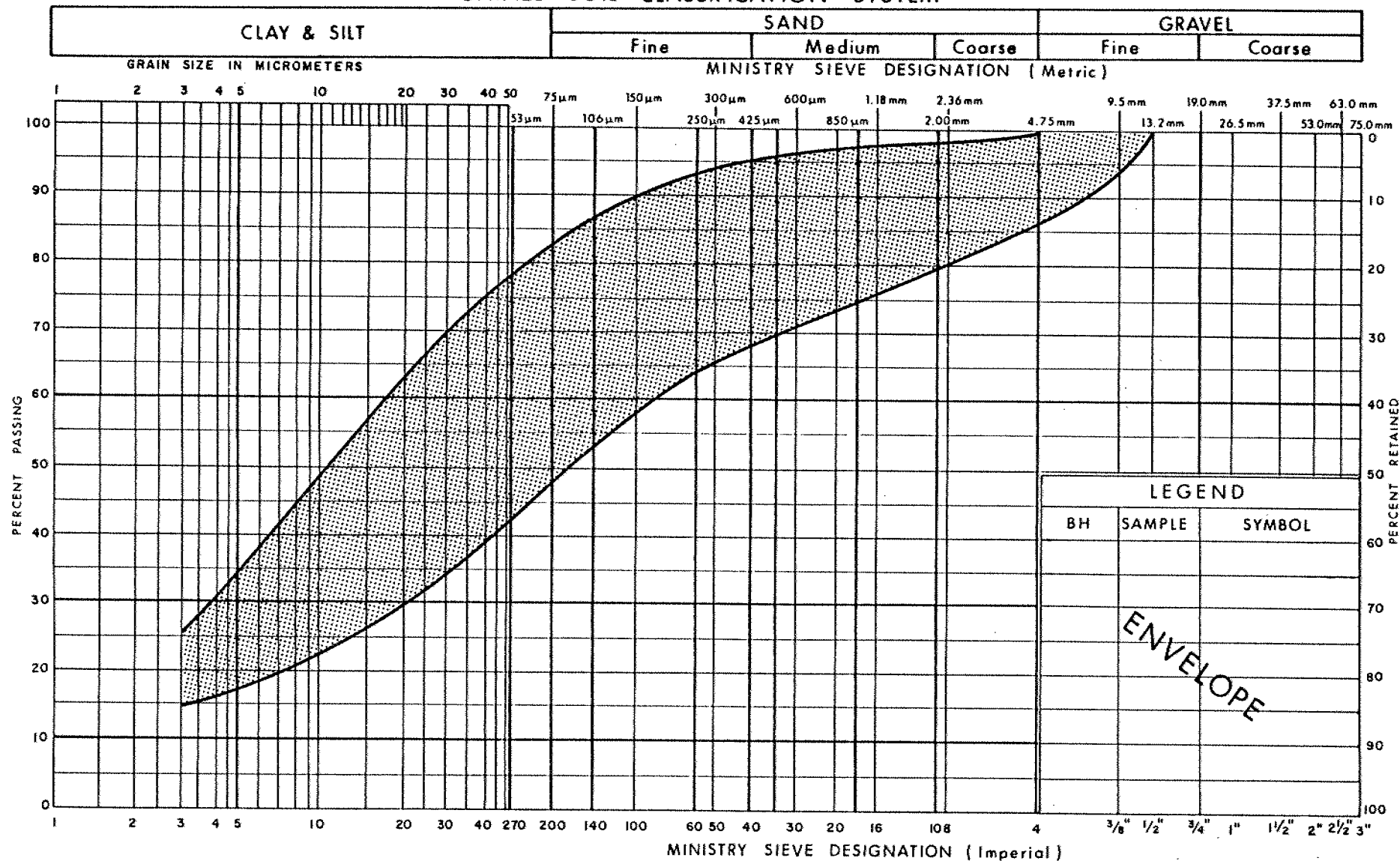
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Ontario

PLASTICITY CHART SILTY CLAY

FIG No 2

W P 142-87-03

UNIFIED SOIL CLASSIFICATION SYSTEM



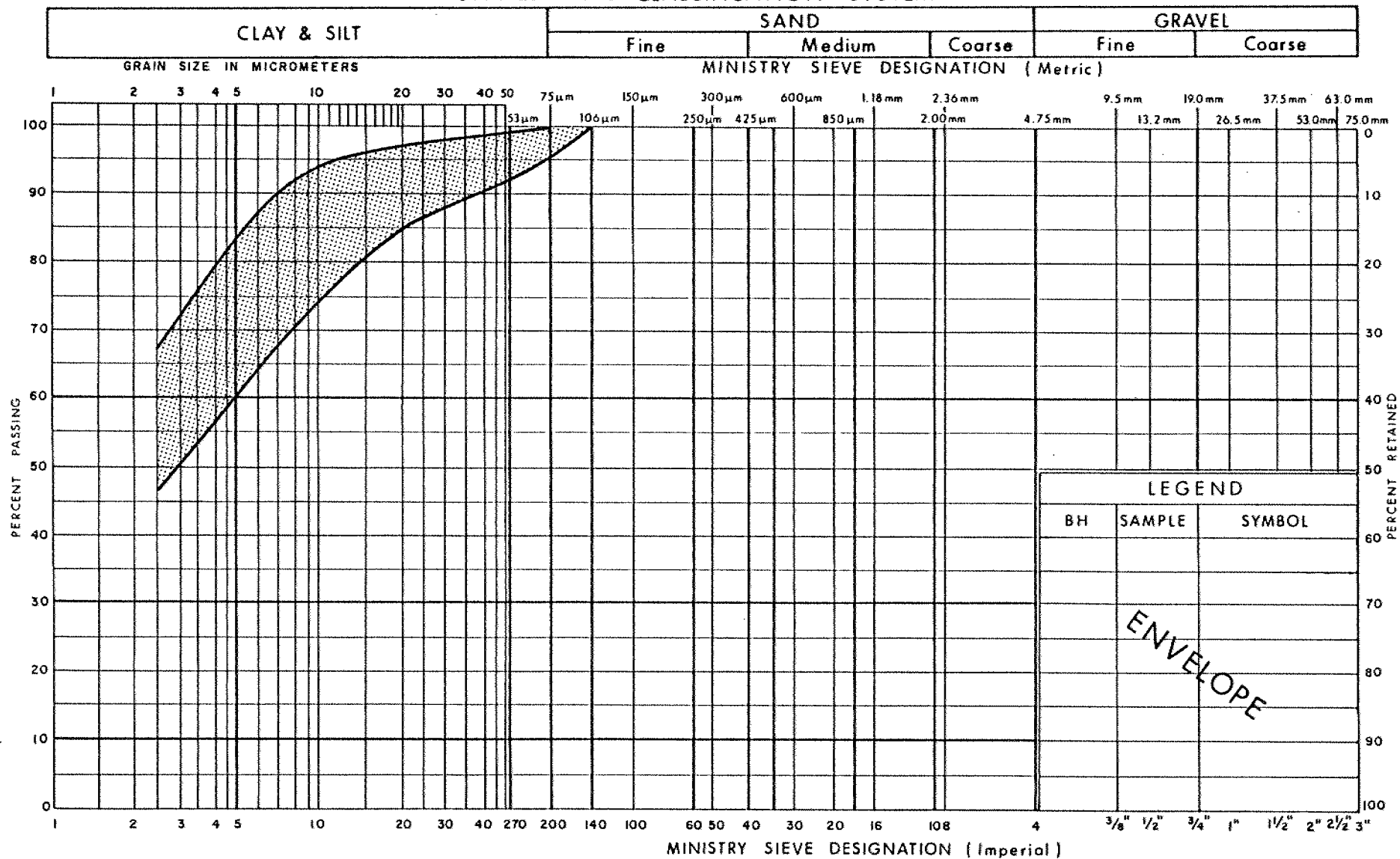
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GRAIN SIZE DISTRIBUTION CLAYEY SILT TO SILT

FIG No 3

W P 142 - 87 - 03

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
SILTY CLAY

FIG No 4

W P 142-87-03

CONT 90-60
ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 138-87-⁰¹~~06~~

DIST 6

HWY 400/407

STR SITE 37-1170

Ramp Structure 407 EW to 400 S
(Over CNR) - Bridge #4

DISTRIBUTION

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M. MacLean (Cover Only)
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FOUNDATION INVESTIGATION REPORT

For

Ramp Structure 407 EW to 400 S

(Over CNR) - Bridge #4

W.P. 138-87-06, Site #37-1170

Hwy. 400/407, District 6, Toronto

INTRODUCTION

This report summarizes the results obtained from a Foundation Investigation implemented at the aforementioned site. A three span structure (15 m-19 m-15 m) will carry traffic over the CNR tracks from 407 EW to 400 S. This report is applicable to the structure and its related retaining walls and approaches.

SITE DESCRIPTION AND GEOLOGY

The site is located approximately 40 metres west of the existing CNR Overhead at Highway 400 in the Town of Vaughan. The CNR tracks bisect the proposed bridge providing rail transportation in an east-west direction.

The terrain surrounding the site is generally flat. Side slopes adjacent to the tracks illustrate the excavation cut required in advancing the CNR tracks. Hydro transmission towers constitute the Hydro corridor approximately 50 metres north of the site and the Steeles ramp to 400 S is located approximately 50 metres south of the site. A single level industrial building exists approximately 1 km northwest of the site.

Geologically, the site is located in the physiographic region known as the Peel Plain. It consists of a bevelled till plain with a gently undulating rolling surface and limited relief. The till plain was deposited by the advance and retreat of the Wisconsin ice sheet during the Pleistocene epoch (over 5,000 years ago).

FIELD INVESTIGATION

Difficulty in obtaining access to the CNR owned area of the site resulted in the field work being divided into two segments. The initial segment involved advancing four sampled boreholes accompanied by dynamic cone penetration tests

outside the CNR property between 88 01 11 and 88 01 14. The subsequent investigation was implemented within the CNR right-of-way between 88 03 24 and 88 03 28 and consisted of six sampled boreholes accompanied by dynamic cone penetration tests.

Continuous flight hollow stem and solid stem auger equipment was used to advance the boreholes with subsoil samples retrieved by a split spoon sampler in accordance with the Standard Penetration Test (ASTM D1586). Washboring methods were required upon encountering the silt-sandy silt layer at boreholes 3 and 4 at elevation 178.5 metres. The samples were identified in the field and then transported to the laboratory for applicable testing on selected samples.

Water levels were obtained in the open boreholes until approximate stabilized levels were observed.

Survey information related to location and elevation of boreholes was provided by Central Region Surveys and Plans.

LABORATORY ANALYSES

To identify the behaviour, gradation and property of the soil, laboratory analyses consisted of:

- 1) Atterberg Limit tests/grain size analyses
- 2) Unit weight determination
- 3) Natural moisture content determination

SUBSURFACE CONDITIONS

In general, reasonably competent and uniform subsurface conditions were encountered across the site. Underlying a thin veneer of topsoil (100 mm), a deposit of clayey silt, some sand and a trace of gravel (glacial till) was founded. The deposit is interbedded with a confined silt-sandy silt layer that was sampled at depths ranging from 4.6 m at the location of the proposed piers

to 7.8 at the remainder of the site. This lacustrine deposit extends to a maximum thickness of 2.0 metres. The consistency of the clayey silt deposit (glacial till) varies from stiff to hard but is predominantly hard.

The boundaries between the various soil types, in-situ and laboratory test results, as well as stabilized ground water levels, are shown on the attached Record of Borehole Sheets. A plan of the site illustrating the locations and elevations of the boreholes and subsoil stratigraphical sections are provided on Dwg. 1388706-A.

A detailed description of the subsurface conditions encountered is given below.

Clayey Silt, some sand, trace gravel (Glacial Till)

Explored to a maximum thickness of 15.7 m, a deposit consisting of clayey silt, some sand, trace gravel exists across the site. Throughout the deposit random silt layers and sand seams were encountered. In the upper metre of the stratum, traces of organics were identified.

The main component of the deposit is a clayey silt (CL) with random zones of less cohesive plastic silt (CL-ML). In general, the stratum is considered cohesive. A grain size distribution envelope for the material as determined by mechanical analyses is given in Figure 1. Atterberg Limits were also obtained to evaluate the behaviour of the fine grained portion of the material and the results are plotted in Figure 2. A summary of the indices of the basic cohesive material matrix is provided in Table 1 below. Unit weights are also included.

TABLE 1

	<u>Range</u>	<u>Avg.</u>
Natural Moisture Content (w%)	7.5-23.5	11.6
Liquid Limit (W _L %)	13-32	20.1
Plastic Limit (W _p %)	10-20.5	13.3
Unit Weight (kN/m ³)	21.4-23.3	22.2

It is evident from the results that the deposit is predominantly of low plasticity. In general, lower moisture contents were observed beneath the cohesionless silt layer founded within the deposit. In addition, the silt content within the till deposit increases beneath the interbedded silt layer and consequently the soil becomes less cohesive and is only slightly plastic.

Boulders and cobbles, although not encountered during the investigation, are characteristic components of till deposits and consequently may be assumed to exist in this deposit.

'N' values obtained as per the Standard Penetration Test indicate that the deposit has a consistency ranging from firm to hard. Generally, the deposit may be considered to be hard. Resistance to driving the split spoon increased beneath the lacustrine confined silt layer where 'N' values were considerably high.

A significant layer of silt interbedded with sand seams exists at elevations ranging from 178.6 m to 179.8 m within the predominant till deposit. This layer is a lacustrine deposit and ranges in denseness from compact to very dense, but is generally in a dense-very dense state. Grain size distribution curves illustrating the gradation of the deposit is provided in Figure 3. The cohesionless layer is water bearing and the fact that the material backed up in the hollow stem augers during drilling indicates that the stratum is perhaps under subartesian head.

GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water level in the open boreholes. Measurements revealed stabilized levels at an elevation ranging from 186.1 metres to 184.4 metres. These elevations correspond to depths below ground surface of 1 to 2 metres at the abutment-retaining wall locations and at the surface at the pier locations. The silt-sandy silt layer confined within the till exhibits a tendency to flow or boil due to conditions of unbalanced hydrostatic head.

DISCUSSION AND RECOMMENDATIONS

A three span ramp structure (15 m-19 m-15 m) is proposed to carry Hwy. 407 E,W traffic over the CNR tracks and onto Hwy. 400 S. The 20 m wide bridge deck will be set at a sloping elevation ranging between 197 m and 198 m. The critical vertical clearance between the bridge deck soffit and rail tracks is 10.57 m. Retaining walls will accompany the overpass structure.

The following itemizes our recommendations for:

- 1) structure foundations
- 2) lateral earth pressures on abutments/retaining walls
- 3) approach fills
- 4) construction considerations

STRUCTURE FOUNDATIONS

The proposed structure may be founded on spread footings in the upper clayey silt deposit or steel H-piles driven to lower depths in the deposit. Major considerations should be given to supporting the retaining walls/abutments on compacted Granular 'A' Fill. The alternative, or combination, which leads to the least expensive design is recommended.

1) Spread Footings on Clayey Silt

The proposed structure may be supported on spread footings founded within the clayey silt deposit. For purposes of the O.H.B.D.C., the following design values are recommended for the elevations provided.

<u>Structure</u>	<u>Recommended Footing Elev.</u>	<u>Bearing Capacity at S.L.S. Type II</u>	<u>Factored Bearing Capacity at U.L.S</u>
North Abutment/ Retaining Walls	184.5	250	375
	182	350	525
South Abutment/ Retaining Walls	184.5	250	375
	182	350	525
North Pier	183.0	500	750
South Pier	183.0	500	750

In view of the overconsolidated nature of the founding soil, differential and total settlements induced should not exceed 25 mm.

The underside of all footings should be provided with a minimum 1.20 metres of earth cover for frost protection.

Sliding resistance between concrete and the foundation soil should be calculated in accordance with Section 6.7.3.3.2. of the O.H.B.D.C. assuming an unfactored adhesion value of 75 kPa. Sliding resistance can be supplemented by constructing shear keys in the founding soil below the base of the footing.

2) Perched Abutments on Compacted Granular 'A' Fill

Alternatively, the abutments and related retaining structures may be supported on spread footings perched within compacted Granular 'A' pads as illustrated in Figure 4 attached in the appendix. All surficial softened and/or organic material within the planned limits of the granular core must be subexcavated prior to its placement. The following design values are recommended:

Factored Capacity at U.L.S.	900 kPa
Allowable Capacity at S.L.S. Type	350 kPa

Sliding resistance may be computed by assuming a coefficient of friction of 0.7 between the underside of the rough concrete footing and the Granular 'A' core.

Settlements induced should not exceed 25 mm.

3) Steel H-Piles

The structure foundations can be founded on deep foundation units driven to end bearing in the lower hard clayey silt deposit. For a steel 'H' section pile equipped with standard reinforced flange tip plates and driven to a minimum set

of 15 blows per 25 mm for all the final 75 mm of placement using a minimum rated driving energy of 48,000 joules/blow, the following design parameters are suggested:

<u>Structure</u>	<u>Pile Type</u>	<u>Capacity at S.L.S. Type II (KN)</u>	<u>Factored Capacity at U.L.S. (KN)</u>	<u>Estimated Pile Tip Elev. (m)</u>
Piers	HP310x79	890	1150	175
	HP310x110	1150	1600	
Abutments/ Retaining Walls	HP310x79	890	1150	174
	HP310x110	1150	1600	

Pile driving in the field should be controlled by employing the Hiley Dynamic Pile Driving Formula.

Abutment pile caps may be perched within the embankment fill provided that particle sizes in the fill immediately beneath the pile locations does not exceed 75 mm. The pile caps should be protected against frost penetration by providing a minimum 1.2 m earth cover.

Total and differential settlements are not anticipated to exceed 25 mm.

Resistance to lateral load shall be computed in accordance with Section 6.8.3.8. of the O.H.B.D.C.

LATERAL EARTH PRESSURES ON ABUTMENTS/RETAINING WALLS

To prevent hydrostatic pressure build-up, backfill to abutments and retaining walls should consist of Granular 'A' or Granular 'B' in accordance with Ministry of Transportation Standards.

Lateral earth pressures should be computed in accordance with Section 6.6.1.2.1 of the O.H.B.D.C. The active condition (K_A) will govern earth pressure design if the structure is yielding while the at rest condition (K_0) will govern for an unyielding structure. The following parameters are provided for earth pressure computation.

<u>Material</u>	<u>ϕ°</u>	<u>γ (kN/m³)</u>	<u>K_A</u>	<u>K_0</u>
Granular 'A'	35	22.8	0.27	0.43
Granular 'B'	30	21.2	0.33	0.50

APPROACH FILLS

Due to the competent nature of the natural soil, no deep-seated failures within this stratum are anticipated. However, the stability of the fills were evaluated and analysed using Bishops total stress method and Spencer's effective stress charts. The following parameters were used for the fill, assuming a unit weight of 20 kN/m³.

a) Total Stress Analysis

- i) Cohesive Fills-Shear Strength (C_u) = 50 kPa
- ii) Granular Fills-Angle of Internal Friction (ϕ°) = 30

b) Effective Stress Analysis

Pore pressure ratio (r_u) = 0.25-0.40

Effective cohesion (c') = 7 kPa

Effective angle of friction (ϕ') = 23°

It can be concluded from the analyses that fills between 9 and 12 m in height will be stable provided that they are constructed at 2H:1V and they include a 2.0 m midheight berm both in the longitudinal and transverse direction. The berm should be constructed with a nominal slope such that surface run-off does not pond on the berm. Fills less than 9 m in height will be stable with 2H:1V slopes.

Any softened and/or organic soil should be removed within the planned limits of the fill prior to its placement.

At the plan limit, a 1:1 transition should be used to bring the excavation backup to original ground. The fills should be placed and compacted according to Ministry of Transportation Standards.

The total amount of settlement of the fill will vary depending on its height. In general, the following settlements can be expected:

<u>Height of Fill (H_{FILL})</u>	<u>Total Settlement (S_T)</u>
0-7 m	0.5% x H _{FILL}
7-10 m	0.75% x H _{FILL}
10-12 m	1% x H _{FILL}

No major settlements are expected in the underlying virgin soil.

CONSTRUCTION CONSIDERATIONS

a) Footing Excavations

In the excavation of the spread footings any loosened/softened soil discovered at the footing foundation elevation shall be removed and replaced with mass concrete or granular fill. In addition, to protect the founding soil from the effects of weathering, it is recommended that a concrete working slab be placed on the soil within 4 hours of exposure.

No major dewatering difficulties are anticipated for footing excavations in consideration of the relatively low permeability of the glacial till deposit. Conventional pumping techniques will suffice in discharging any localized seepage.

b) Track Protection

In view of the close proximity of the railroad tracks to the south pier footings, a temporary shoring scheme should be provided during the

excavation and construction of the foundation. A soldier pile-timber lagging cantilever system is recommended with soldier piles installed by either driven or augering techniques. Earth pressures are to be computed in accordance with Section 6.6.1.2 of the O.H.B.D.C. For design purposes, the following parameters are recommended:

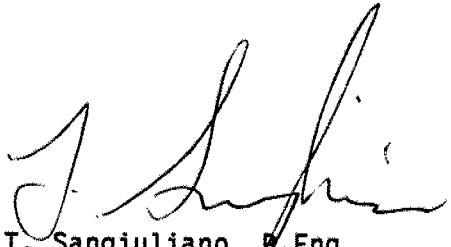
<u>Stratum</u>	<u>γ</u> (kN/m ³)	<u>C_u</u> (kPa)	<u>ϕ</u>
Clayey Silt (Glacial Till)	22	150	-
Silt (Lacustrine)	20	-	30°

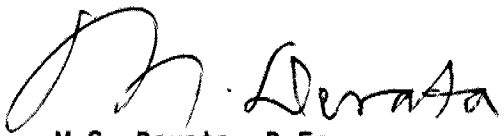
Upon completion of the foundation work, the soldier piles should be cut off 1 m below the final grade and left in place.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of T. Sangiuliano, Foundation Engineer, utilizing equipment owned and operated by Master Soil Drilling, Toronto. This report was written by T. Sangiuliano and reviewed by Mr. M.S. Devata, Chief Foundation Engineer (East).

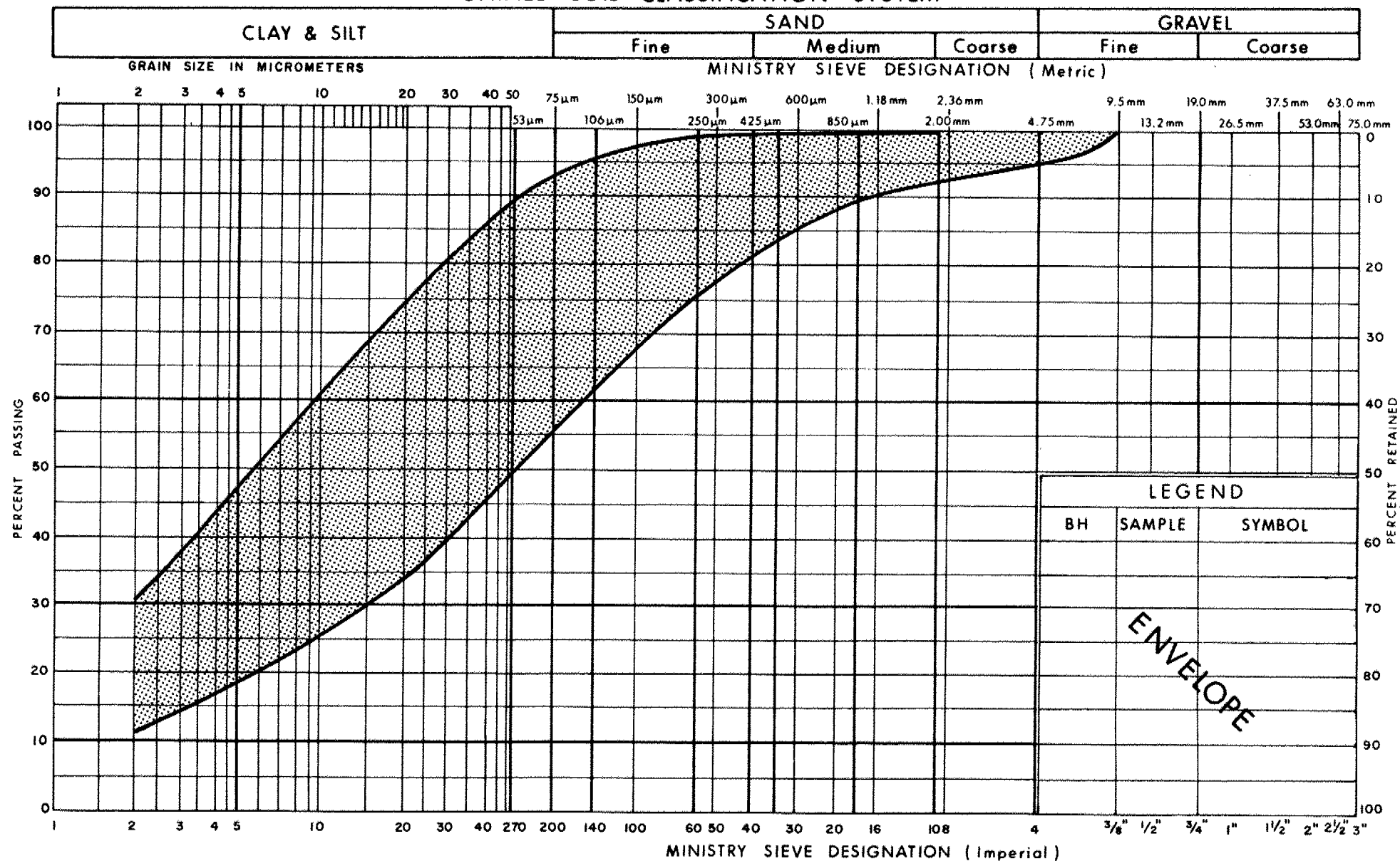



T. Sangiuliano, P.Eng.
Foundation Engineer


M.S. Devata, P.Eng.
Chief Foundation Engineer
(East)

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM

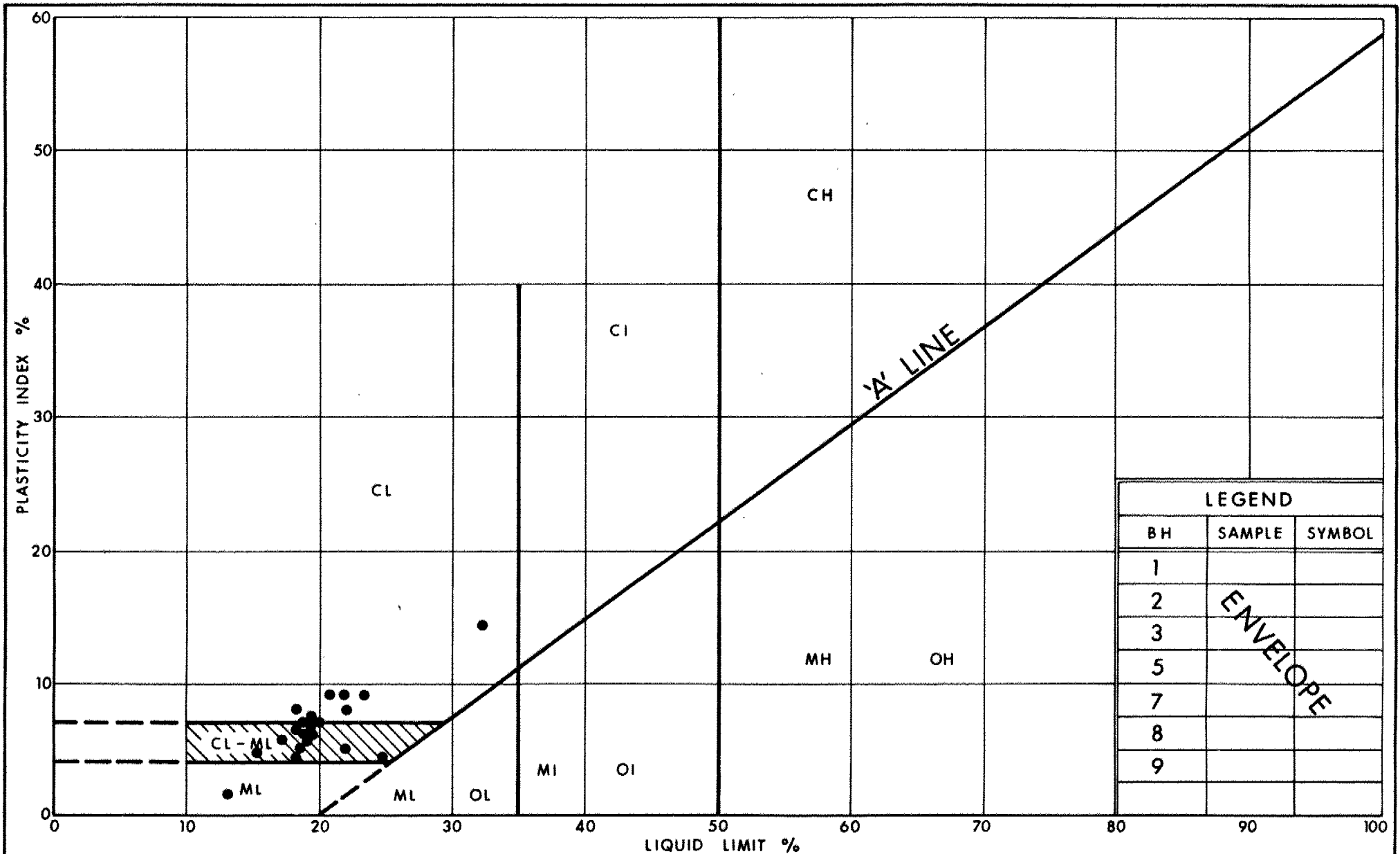


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GRAIN SIZE DISTRIBUTION
CLAYEY SILT WITH/SOME SAND, TRACE GRAVEL
(Glacial Till)

FIG No 1

W P 138-87-06



Ministry of
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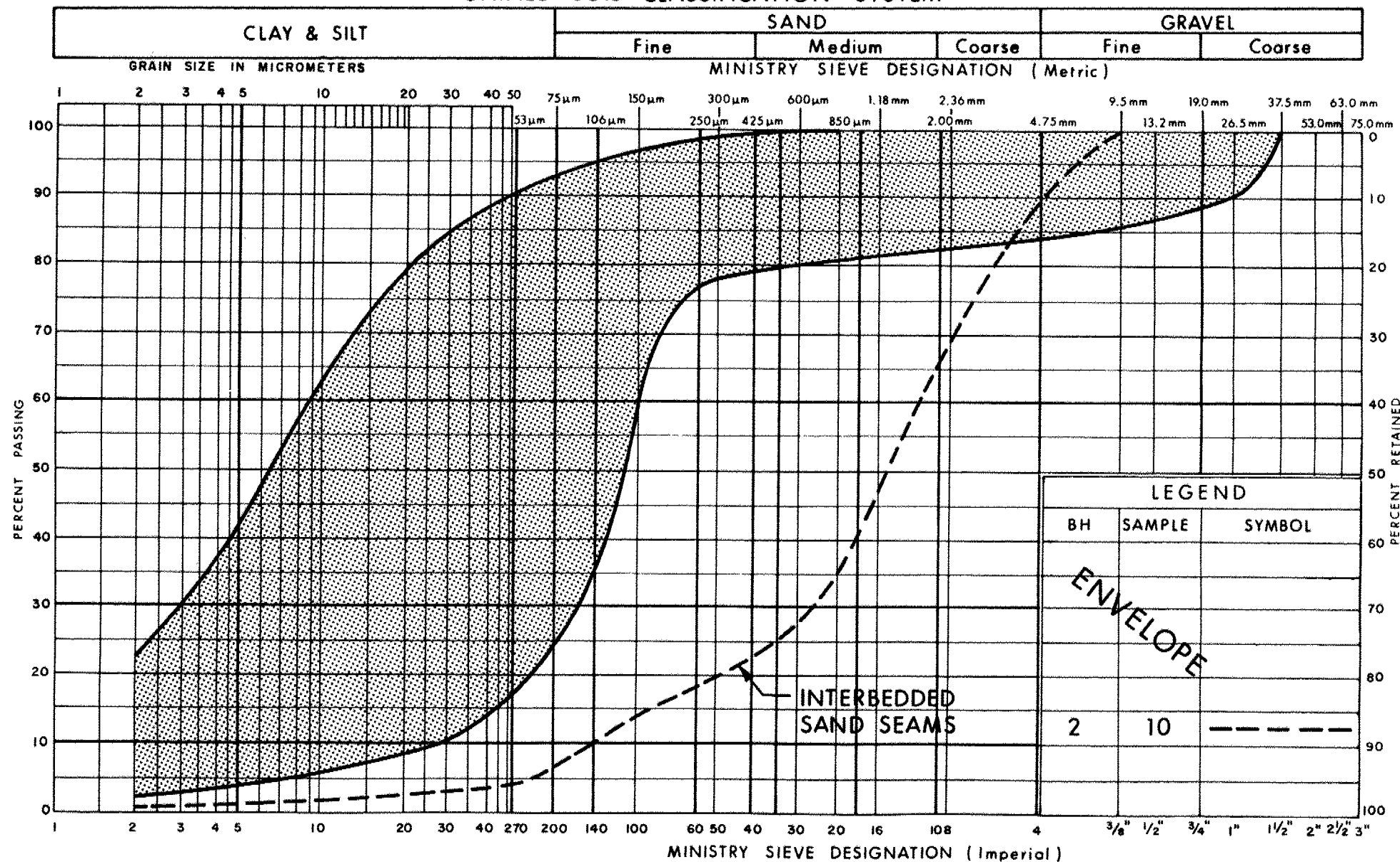
Ontario

PLASTICITY CHART CLAYEY SILT, SOME / WITH SAND, TRACE GRAVEL (Glacial Till)

FIG No 2

W P 138-87-06

UNIFIED SOIL CLASSIFICATION SYSTEM

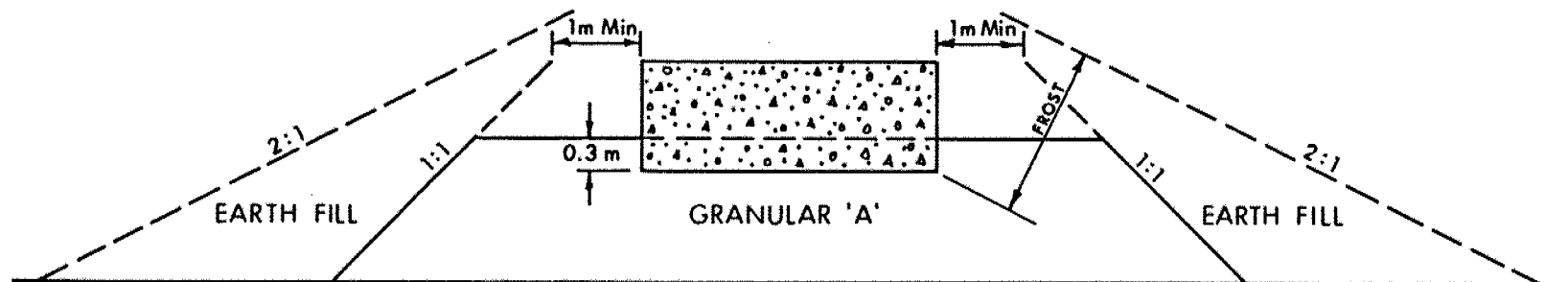


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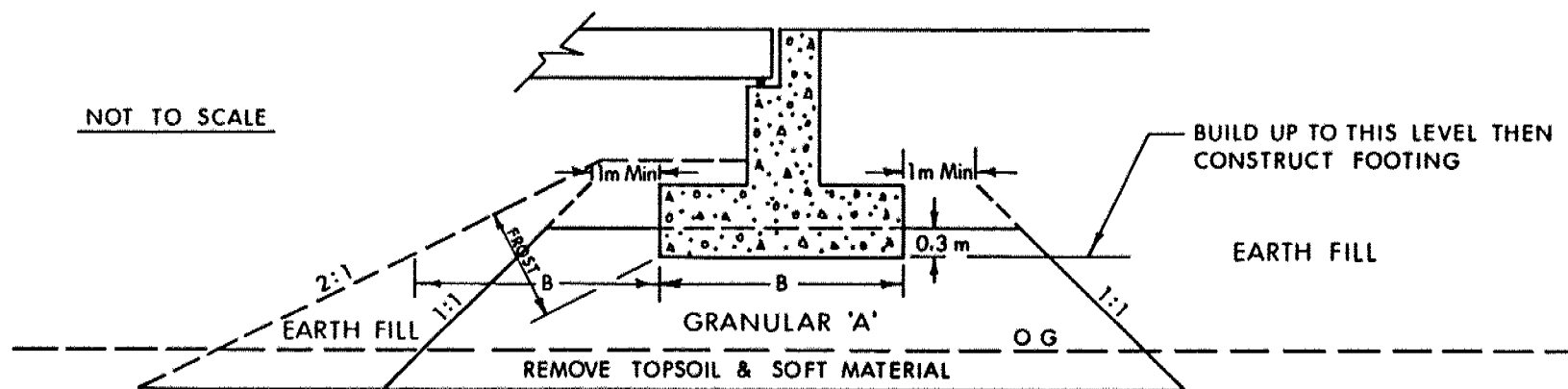
GRAIN SIZE DISTRIBUTION
SILT WITH SAND, TRACE GRAVEL
AND INTERBEDDED SAND SEAMS

FIG No 3

W P 138-87-06



X SECTION



LONGITUDINAL SECTION

NOTES:

- 1 - REMOVE TOPSOIL & /OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' & EARTH FILL.
- 2 - PLACE GRANULAR 'A' & EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO CURRENT M T C STANDARDS.
- 3 - CONSTRUCT CONCRETE FOOTING.
- 4 - PLACE REMAINDER OF GRANULAR 'A' & EARTH FILL AS REQUIRED.



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ABUTMENT ON COMPACTED FILL
SHOWING GRANULAR 'A' CORE

FIG No 4

W P 138-87-06

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3 m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_a	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_f	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

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
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{\min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m^3	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m^3	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL	e_{\max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m^3	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

RECORD OF BOREHOLE No 1

METRIC

W P 138-87-06 LOCATION Co-ords. N 4 848 306.8; E 301 814.2 ORIGINATED BY TS
DIST 6 HWY 400 BOREHOLE TYPE Hollow Stem Auger, Washbore & Cone Test COMPILED BY TS
DATUM Geodetic DATE 88 01 11 - 12 CHECKED BY

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			20	40						60	80	100	WATER CONTENT (%)	GR SA SI CL
								SHEAR STRENGTH kPa											
186.8	Ground Surface																		
0.0	Topsoil																		
	Clayey Silt		1	SS	15								21.7	1 6 33 60					
	Some Sand		2	SS	15														
	Trace Gravel		3	SS	22														
	(Glacial Till)		4	SS	13														
	Stiff to V. Stiff		5	SS	70														
	Hard		6	SS	72														
	Random Zones		7	SS	54														
	of Silt		8	SS	41														
178.6			9	SS	54								20.6	4 20 60 16					
8.2	Silt with Sand																		
177.2	V. Dense (Lacustrine)		10	SS	62									16 25 58 1					
9.6			11	SS	120														
			12	SS	100/15 cm									2 32 50 16					
			13	SS	100/15 cm														
171.1			14	SS	100														
15.7	End of Borehole																		
	*NOTE Soil backed up in augers at 8.2 m. Advance by washboring inside augers.																		

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 2

METRIC

W P 138-87-06 LOCATION Co-ords. N 4 848 311.1; E 301 830.4 ORIGINATED BY TS
DIST 6 HWY 400 BOREHOLE TYPE Hollow Stem Auger & Cone Test COMPILED BY TS
DATUM Geodetic DATE 88 01 12 CHECKED BY

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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
187.3	Ground Surface													
0.0	Topsoil													
	Clayey Silt with Sand, Trace Gravel		1	SS	12									
	Stiff		2	SS	16									
	to V. Stiff		3	SS	18									
	Hard		4	SS	38									
	Brown Grey		5	SS	55									
	(Glacial Till)		6	SS	30									
	Random Zones of Silt		7	SS	46									
			8	SS	30									
179.7														
7.6	Silt with interbedded Sand Seams, compact to V. Dense		9	SS	23									
	(Lacustrine)		10	SS	55									
177.7														
9.6			11	SS	91									
			12	SS	100	15 cm								
173.1														
14.2	End of Borehole		13	SS	105									

RECORD OF BOREHOLE No 3

METRIC

W P 138-87-06 LOCATION Co-ords. N 4 848 240.0; E 301 830.0 ORIGINATED BY TS
DIST 6 HWY 400 BOREHOLE TYPE Hollow Stem Auger, Washbore & Cone Test COMPILED BY TS
DATUM Geodetic DATE 88 01 13 CHECKED BY

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			20 40 60 80 100	SHEAR STRENGTH kPa		WATER CONTENT (%)			
186.3	Ground Level							○ UNCONFINED + FIELD VANE	10 20 30					GR SA SI CL
0.0	Topsoil						186	● QUICK TRIAXIAL x LAB VANE						
	Some Organics		1	SS	13		184							
	Clayey Silt		2	SS	9		182						23.3	1 20 62 17
	Some Sand		3	SS	14		180						22.6	
	Trace Gravel		4	SS	6		178							2 71 23 4
	(Glacial Till)		5	SS	28		176							3 33 52 12
	Brown Grey		6	SS	65		174							3 32 47 18
	Firm to V. Stiff		7	SS	65									
	Hard		8	SS	38	*								
	Random Zones of Silt		9	SS	26									
178.7			10	SS	100									
7.6	Sand, Some Silt		11	SS	100/	15 cm								
	Compact - Dense		12	SS	100/	15 cm								
176.7	(Lacustrine)													
9.6														
172.3														
14.0	End of Borehole													
<p><u>*NOTE</u> Soil backed up in augers at 8.5 m. Advance by washboring inside augers.</p>														

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 4

METRIC

W P 138-87-06 LOCATION Co-ords. N 4 848 245.0; E 301 846.0 ORIGINATED BY TS
DIST 6 HWY 400 BOREHOLE TYPE Hollow Stem Auger, Washbore & Cone Test COMPILED BY TS
DATUM Geodetic DATE 88 01 13 - 14 CHECKED BY



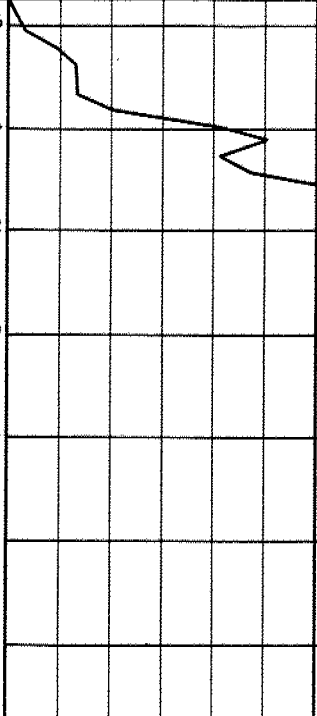
OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
186.5	Ground Level										
0.0	Topsoil										
	Some Organics		1	SS	16						
	Clayey Silt		2	SS	11						
	Some Sand		3	SS	24						
	Trace Gravel		4	SS	9						
	(Glacial Till)		5	SS	27						
	Stiff to V. Stiff		6	SS	30						
	Hard		7	SS	47						
	Random Zones of Silt		8	SS	92						
178.9											
7.6	Silt with Sand		9	SS	26						1 37 61 1
	Compact										
176.9	(Lacustrine)		10	SS	28						
9.6											
			11	SS	100/15 cm						
			12	SS	100/20 cm						4 31 50 15
172.5			13	SS	100						
14.0	End of Borehole										
<p>*NOTE Soil backed up in augers at 8.5 m. Advance by washboring inside augers.</p>											

RECORD OF BOREHOLE No 5

METRIC

W P 138-87-06 LOCATION Co-ords. N 4 848 295.1; E 301 832.4 ORIGINATED BY TS
DIST 6 HWY 400 BOREHOLE TYPE Cone Test, Solid Stem Auger COMPILED BY TS
DATUM Geodetic DATE 88 03 24 CHECKED BY

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						
								SHEAR STRENGTH kPa						
							○ UNCONFINED	+ FIELD VANE			WATER CONTENT (%)			
							● QUICK TRIAXIAL	x LAB VANE			10 20 30			
186.5	Ground Surface													
0.0	Clayey Silt Some Sand Trace Gravel (Glacial Till) Stiff to V. Stiff Hard Random Zones of Silt		1	SS	16		186					20.4	0 9 29 62	
			2	SS	25		184							
			3	SS	25									
			4	SS	27									
			5	SS	42									
			6	SS	74									
			7	SS	100									
			8	SS	50									
178.9													22.1	1 19 56 24
7.6	Silt with Sand Compact (Lacustrine)	9	SS	16			178							
177.4														
9.1		10	SS	110										
		11	SS	100	15 cm		176							

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 6

METRIC

W P 138-87-06 LOCATION Co-ords. N 4 848 292.0; E 301 820.0 ORIGINATED BY TS
DIST 6 HWY 400 BOREHOLE TYPE Cone Test, Solid Stem Auger COMPILED BY TS
DATUM Geodetic DATE 88 03 24 CHECKED BY

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	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100					
186.8	Ground Surface												
0.0	Clayey Silt with Sand Trace Gravel (Glacial Till)		1	SS	24								
			2	SS	22								
	V. Stiff Hard	Brown Grey	3	SS	27								
			4	SS	55								
			5	SS	51								
	Random Zones of Silt		6	SS	61								
			7	SS	77								
			8	SS	51								
179.2													
7.6	Silt with Occ. Sand Pockets		9	SS	41								1 18 63 18
177.7	Dense (Lacustrine)		10	SS	49								
9.1													
			11	SS	100/15 cm								
			12	SS	100/15 cm								
172.6													
14.2	End of Borehole		13	SS	120								

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 7

METRIC

W P 138-87-06 LOCATION Co-ords. N 4 848 284.2; E 301 829.9 ORIGINATED BY TS
 DIST 6 HWY 400 BOREHOLE TYPE Cone Test, Solid Stem Auger COMPILED BY TS
 DATUM Geodetic DATE 88 03 24 CHECKED BY

OFFICE REPORT ON SOIL EXPLORATION

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa					
184.4	Ground Surface							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						
0.0	Stiff Hard		1	SS	14		184						23.0	2 20 58 20
	Clayey Silt		2	SS	66		182							
	Some Sand		3	SS	82									
	Trace Gravel		4	SS	62									
	(Glacial Till) Grey		5	SS	41		180							
	Random Zones		6	SS	54									
179.8	of Silt		7	SS	21									
4.6	Sandy Silt		8	SS	59		178							
	Compact - V. Dense		9	SS	121/	23 cm	176							
	(Lacustrine)		10	SS	100/	12 cm	174							
177.8			11	SS	125/	23 cm								
6.6			12	SS	123/	15 cm	172							
171.9	End of Borehole													
12.5														

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 8

METRIC

W P 138-87-06 LOCATION Co-ords. N 4 848 267.0; E 301 834.0 ORIGINATED BY TS
 DIST 6 HWY 400 BOREHOLE TYPE Cone Test, Solid Stem Auger COMPILED BY TS
 DATUM Geodetic DATE 88 03 25 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT Wp NATURAL MOISTURE CONTENT W LIQUID LIMIT WL WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ KN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
185.0	Ground Surface										
0.0											
			1	SS	7		184				
			2	SS	80						
			3	SS	58						
			4	SS	80						
			5	SS	70						
			6	SS	65						
179.7	Random Zones of Silt		7	SS	70						
5.3	Silt with interbedded Sand Seams, V. Dense (Lacustrine)		8	SS	100						
178.0			9	SS	60/8 cm						
7.0			10	SS	100/8 cm						
			11	SS	60/8 cm						
172.4			12	SS	100						
12.6	End of Borehole										

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 9

METRIC

W P 138-87-06 LOCATION Co-ords. N 4 848 259.0; E 301 841.0 ORIGINATED BY TS
 DIST 6 HWY 400 BOREHOLE TYPE Cone Test, Solid Stem Auger COMPILED BY TS
 DATUM Geodetic DATE 88 03 25-28 CHECKED BY

OFFICE REPORT ON SOIL EXPLORATION

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						
186.5	Ground Surface													
0.0	Clayey Silt Some Sand Trace Gravel (Glacial Till)		1	SS	13		186							
			2	SS	15		184							
	Stiff to V. Stiff	Brown Grey	3	SS	28								21.4	4 26 53 17
	Hard		4	SS	14									
			5	SS	44									
			6	SS	40									
	Random Zones of Silt		7	SS	65									
			8	SS	60									
178.9							182							
7.6	Silt Occ. Sand Seams Dense (Lacustrine)		9	SS	48		180							1 7 72 20
176.9			10	SS	31		178							
9.6							176							
			11	SS	100/	15 cm	174							
			12	SS	100/	15 cm								
172.5														
14.0	End of Borehole		13	SS	100/	15 cm								1 36 50 13



RECORD OF BOREHOLE No 10

METRIC

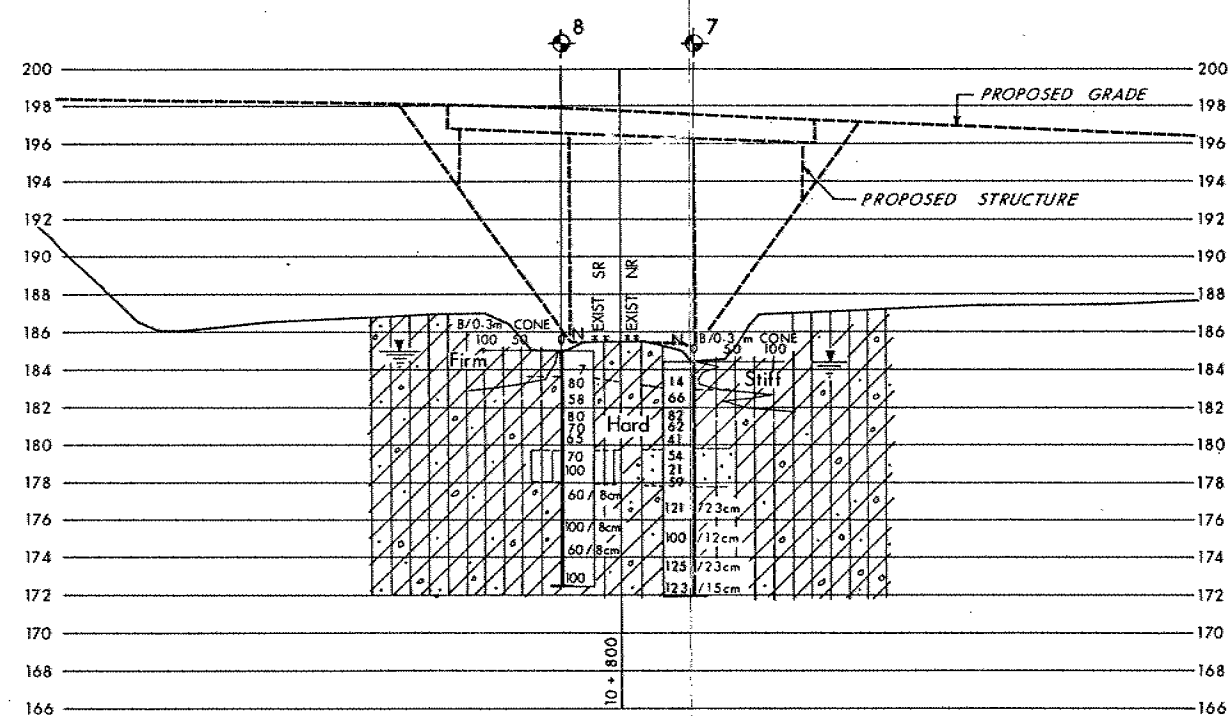
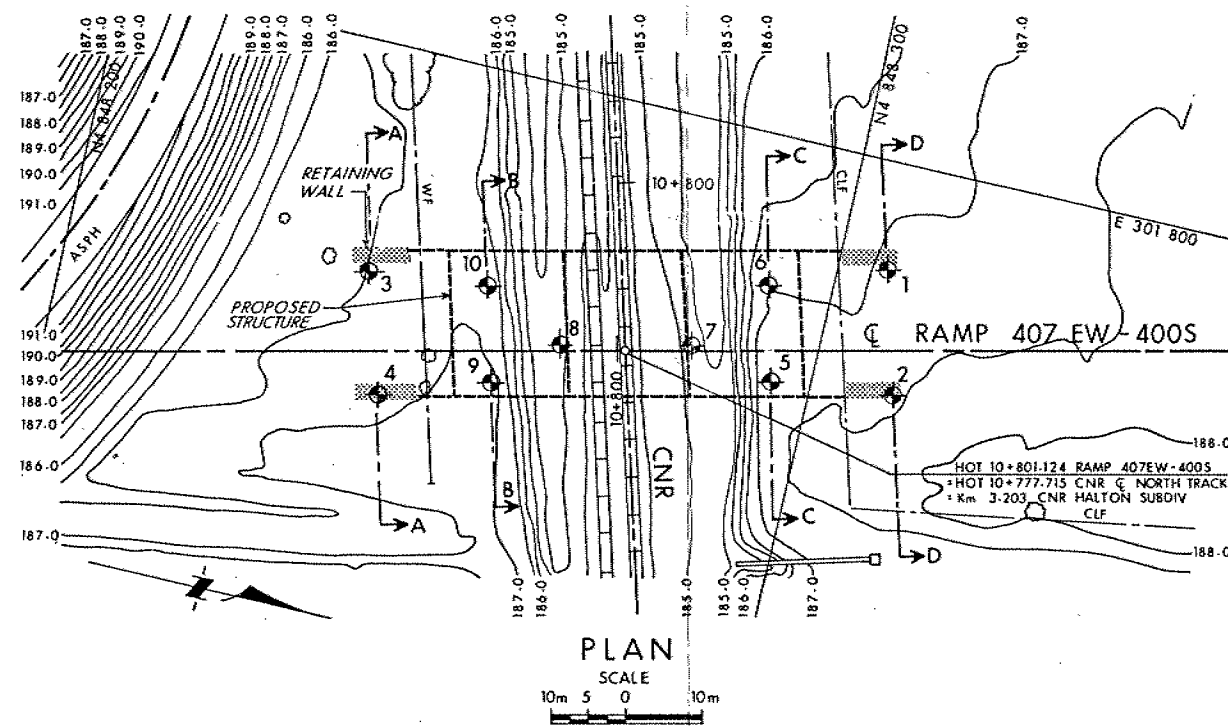
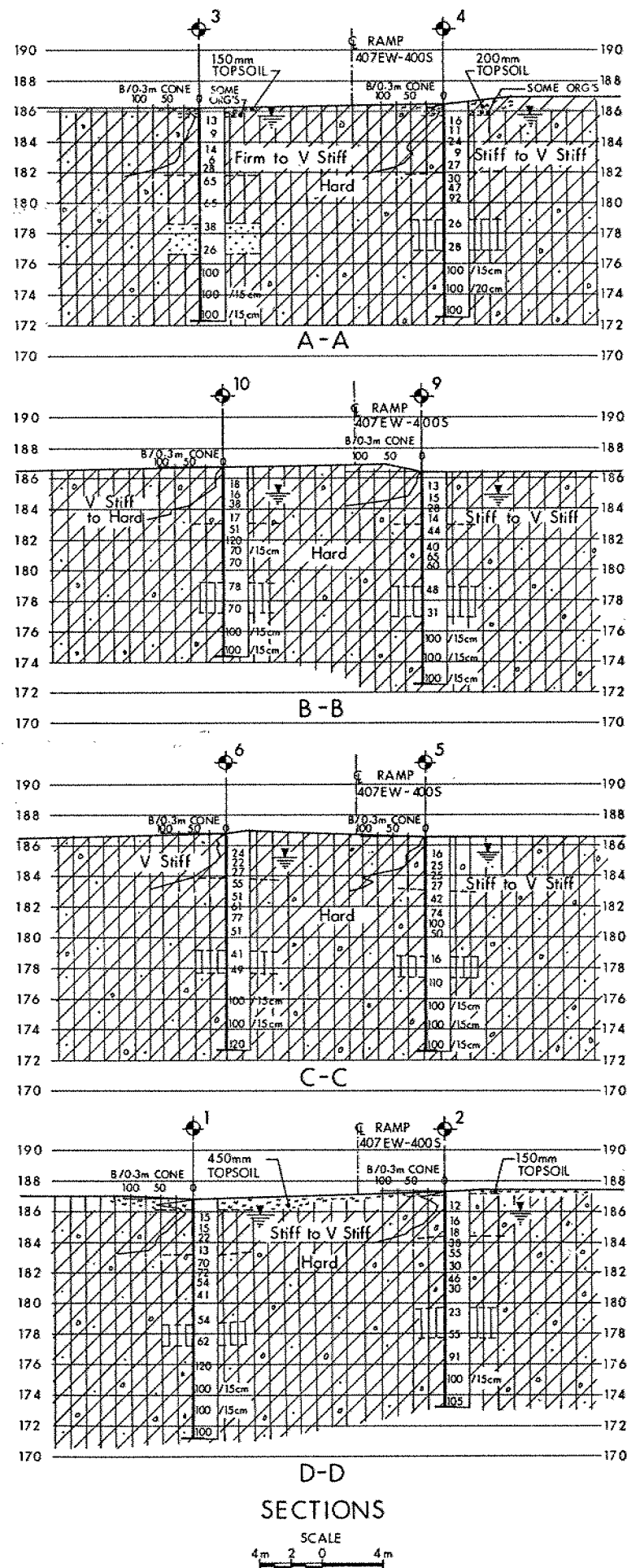
W P 138-87-06 LOCATION Co-ords. N 4 848 255.9; E 301 828.5 ORIGINATED BY TS
DIST 6 HWY 400 BOREHOLE TYPE Cone Test, Solid Stem Auger COMPILED BY TS
DATUM Geodetic DATE 88 03 28 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES							
186.8	Ground Surface											
0.0			1	SS	18							
			2	SS	16							
			3	SS	38							
			4	SS	17							
			5	SS	51							
			6	SS	120							
			7	SS	70	15 cm						
			8	SS	70							
179.2												
7.6			9	SS	78							
177.2			10	SS	70							
9.6												
			11	SS	100	15 cm						
174.3												
			12	SS	100	15 cm						
12.5	End of Borehole											

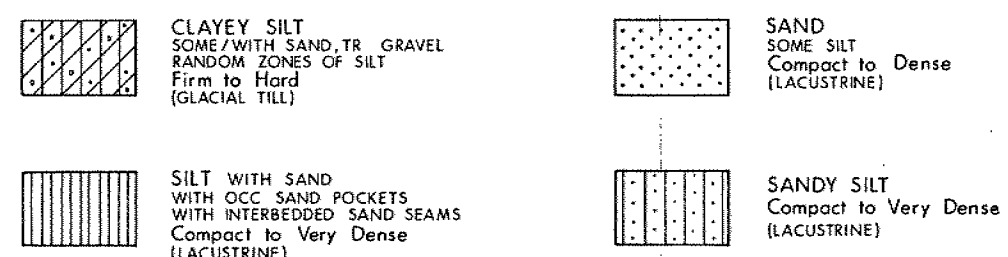
+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION



SOIL STRATIGRAPHY LEGEND



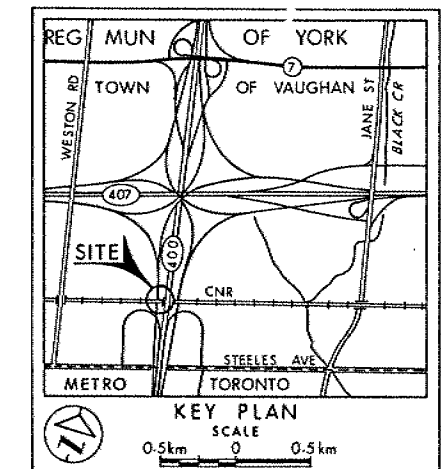
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES.

CONT No
WP No 138-87-06

RAMP 407 EW TO 400S
(OVER CNR) - BRIDGE-4

BORE HOLE LOCATIONS & SOIL STRATA

SHEET



LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L. at time of investigation
88 01 and 88 03

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	186.8	4 848 306.8	301 814.2
2	187.3	4 848 311.1	301 830.4
3	186.3	4 848 240.0	301 830.0
4	186.5	4 848 245.0	301 846.0
5	186.5	4 848 295.1	301 832.4
6	186.8	4 848 292.0	301 820.0
7	184.4	4 848 284.2	301 829.9
8	185.0	4 848 267.0	301 834.0
9	186.5	4 848 259.0	301 841.0
10	186.8	4 848 255.9	301 828.5

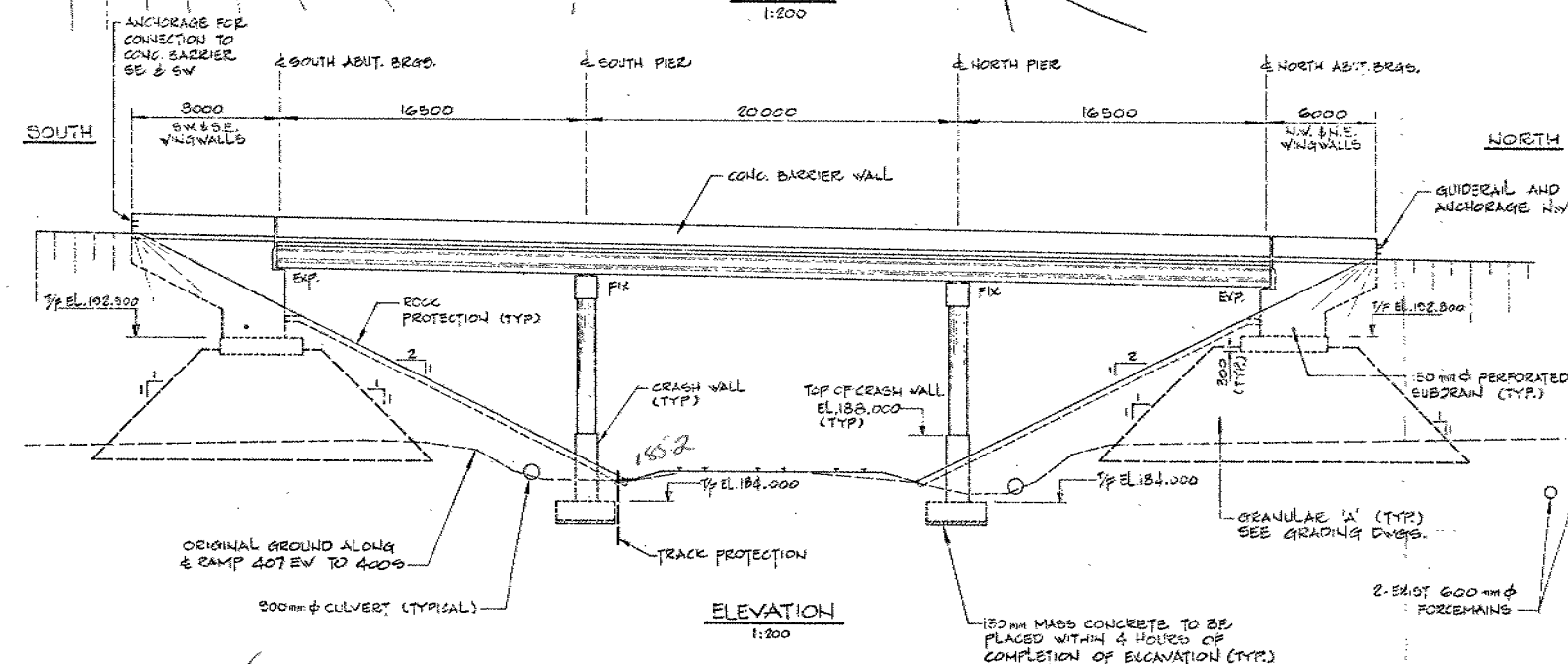
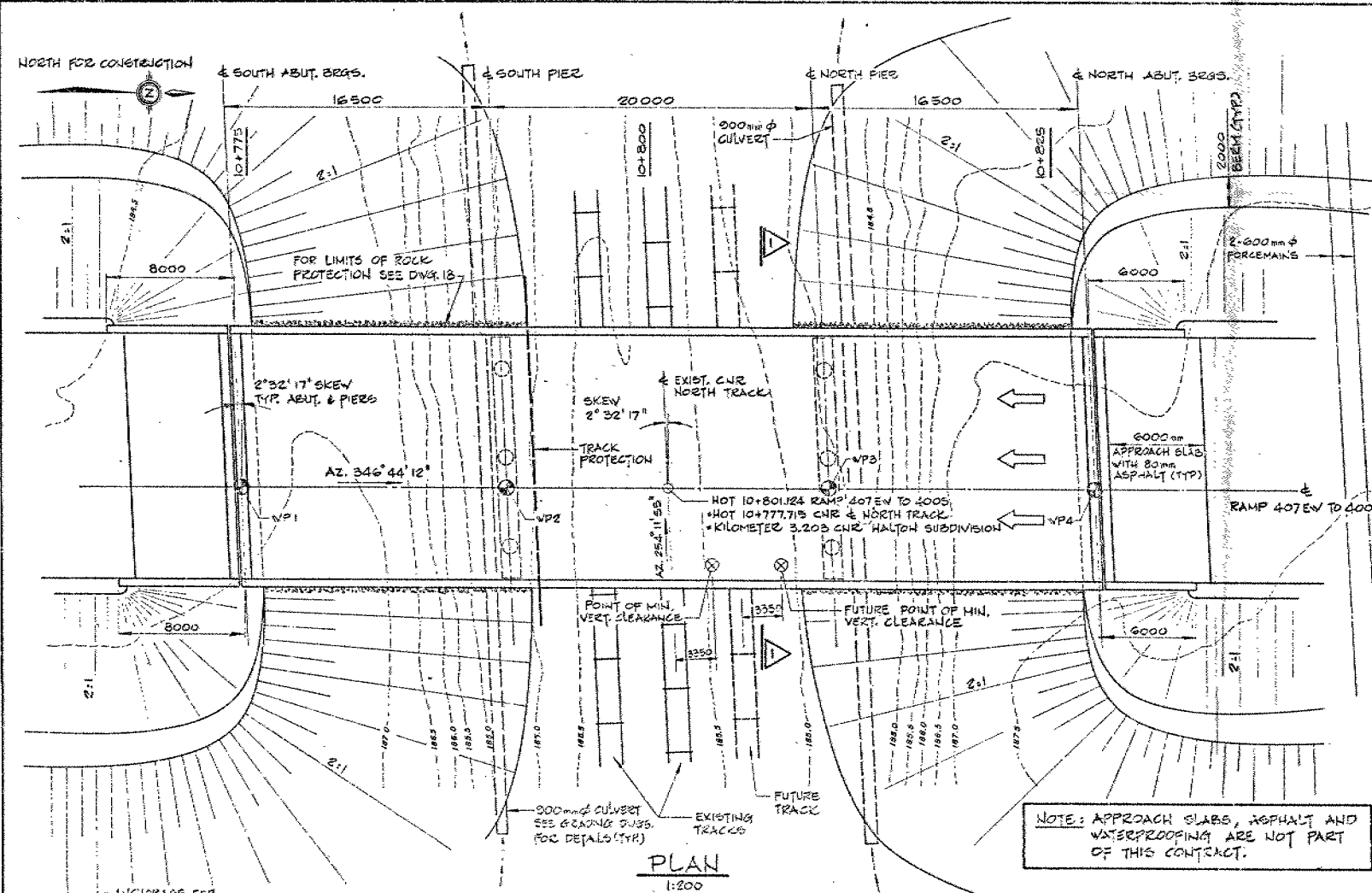
NOTE
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REV	DATE	BY	DESCRIPTION
1			

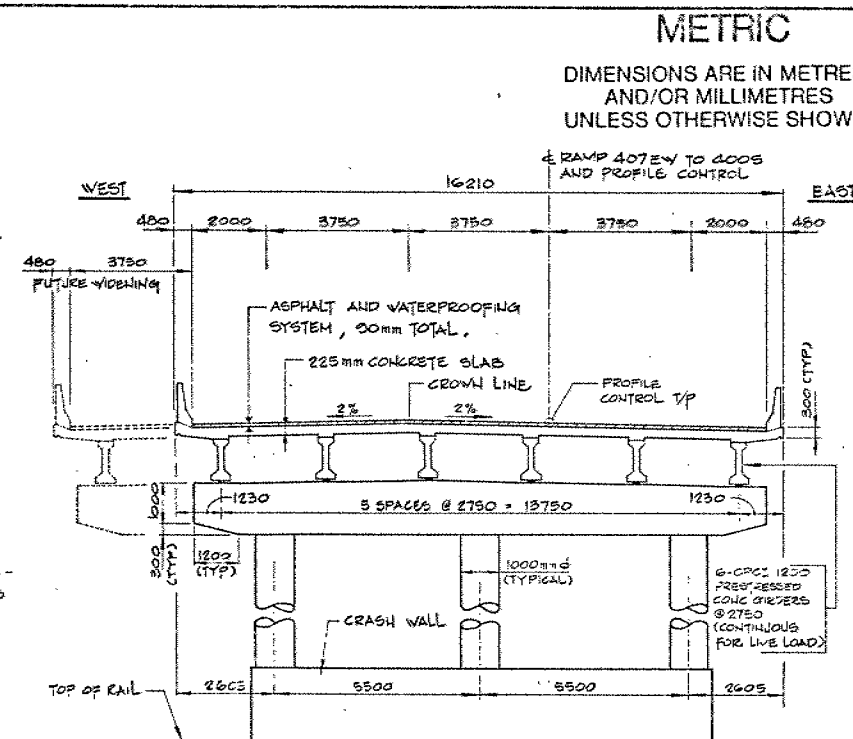
Geocres No 30M13-82

HWY No 400	DIST 6
SUBM'D TS CHECKED	DATE 88 05 27
DRAWN DT CHECKED	SITE 37-1170
	DWG 1388706-A



WORKING POINT DATA		
	STATION AT & RAMP 407EW TO 400S	PROFILE CONTROL TYP ELEVATION
WP 1	10+772.624	135.076
WP 2	10+791.124	137.823
WP 3	10+811.124	137.515
WP 4	10+827.624	137.213

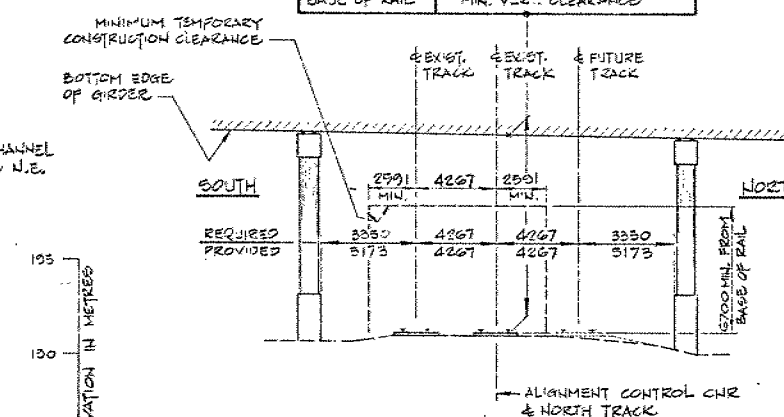
BENCH MARK
ELEV. 194.312 GEODETIC DATUM
CC ON SE CORNER OF CONC. BRIDGE
17.0 RT. 10+47.9 (2 HAY, 400)



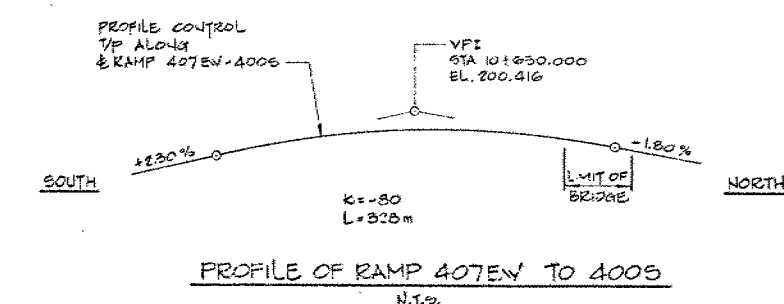
LIST OF ABBREVIATIONS

TP DENOTES TOP OF PAVEMENT
W.P. DENOTES WORKING POINT

REQUIRED	PROVIDE
7163 mm FROM BASE OF RAIL	10337 mm FROM BASE OF RAIL MIN. VERT. CLEARANCE



MINIMUM RAILWAY CLEARANCE DIAGRAM
DIMENSIONS ARE PERPENDICULAR TO TRACKS
N.T.S.



DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

DIST. No. 6

CONT No
WP No 138-87-01

CNR OVERPASS

GENERAL ARRANGEMENT

DILLON
Consulting Engineers • Planners
Environmental Scientists

NOTES:

CLASS OF CONCRETE

PRESTRESSED GIRDERS 35 MR

PIERS 30 MPa

TRACK PROTECTION, MASS CONCRETE - 20 MPa

FOOTINGS 30 MPa

REMAINDER ————— 30 MPa

REINFORCING STEEL

REINFORCING STEEL SHALL BE GRADE 400
UNLESS OTHERWISE SPECIFIED.

BAR MARKS WITH SUFFIX 'C' DENOTE COATED BARS.

CLEAR COVER TO REINFORCING STEEL

FOOTINGS _____ 100+25

ABUTMENTS AND

WING WALLS ----- OUTSIDE FACE ----- 80 ± 20

INSIDE FACE — 70 ± 20
DECK TOP — 70 ± 20

BOTTOM ————— 40 ± 10

FIERS 80 ± 20

REMAINDER, UNLESS NOTED OTHERWISE — 70 ± 20

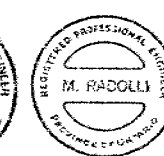
LIST OF DRAWINGS

1. GENERAL ARRANGEMENT
2. BOREHOLE LOCATION AND SOIL STRATA
3. TRACK PROTECTION
4. FOOTING LAYOUT AND REINFORCEMENT
5. SOUTH ABUTMENT DETAILS AND REINFORCEMENT
6. NORTH ABUTMENT DETAILS AND REINFORCEMENT
7. E & S Y WINGWALL DETAILS AND REINFORCEMENT
8. W & NE WINGWALL DETAILS AND REINFORCEMENT
9. PIER LAYOUT AND REINFORCEMENT
10. PRESTRESSED GIRDERS
11. DECK LAYOUT
12. DECK REINFORCEMENT
13. 6000 mm APPROACH SLAB
14. BARRIER WALL
15. JOINT ANCHORAGE AND ARMOURING
16. AS CONSTRUCTED ELEV & DIM
17. BRIDGE DATA & NUMBER DATA
18. STANDARD DETAILS
19. QUANTITIES - STRUCTURE - I
20. QUANTITIES - STRUCTURE - II

STANDARD DRAWINGS

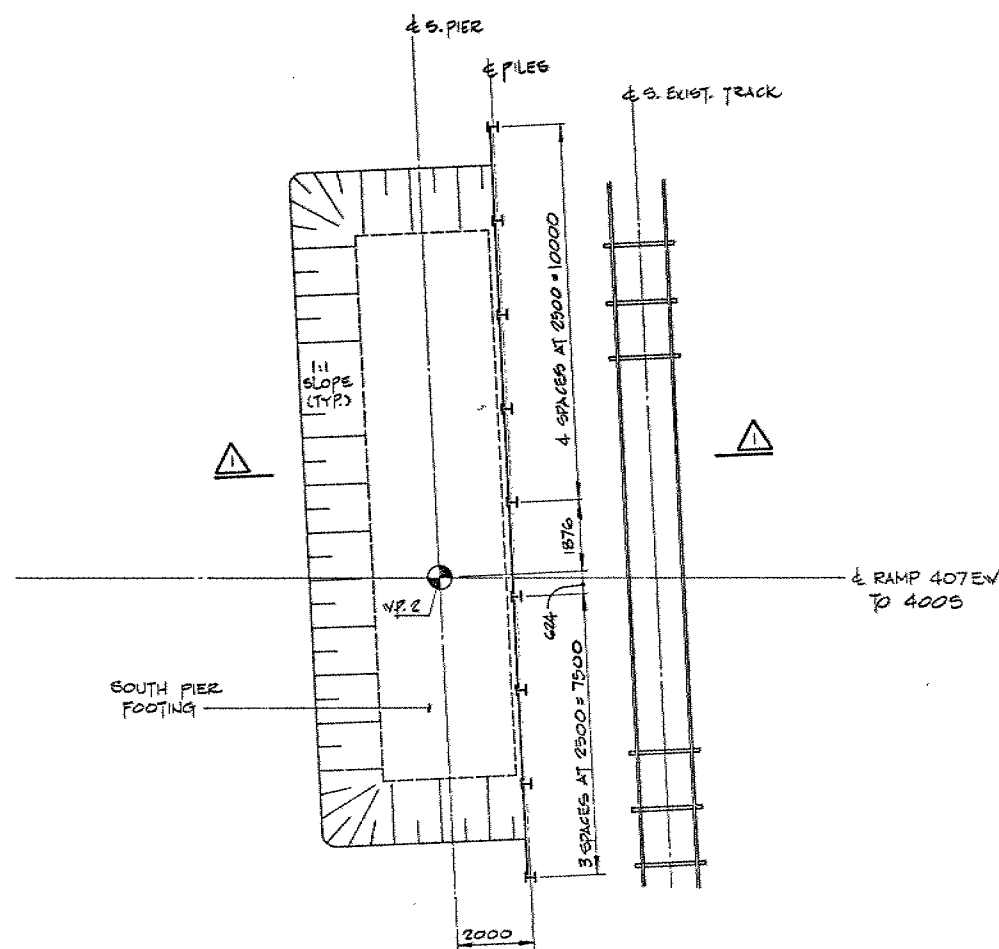
OPSD-508.02 BRIDGE DECK WATERPROOFING

DO-3503 MINIMUM GRANULAR BACKFILL REQUIREMENTS.

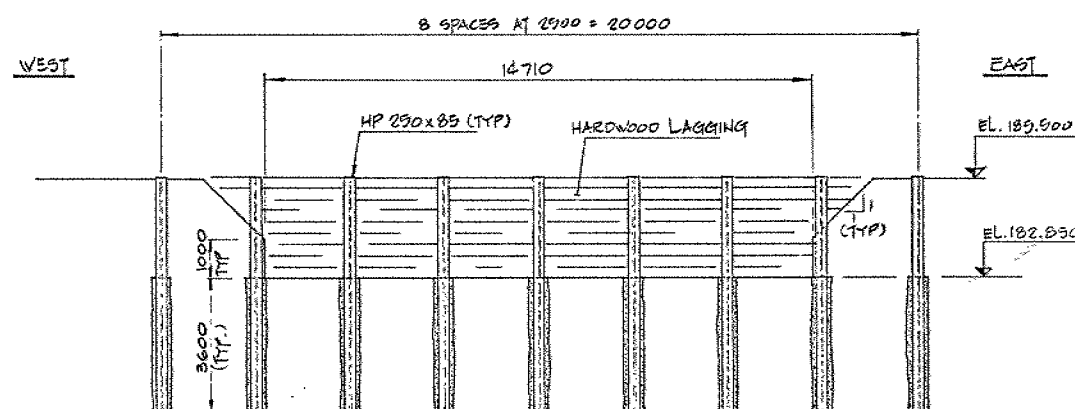


PERSONS										
	DATE	BY	DESCRIPTION							
	DESIGN	MR	CHK	RAR	CODE	OMBC-83	LOAD	CLASS-A	DATE	FEB 89
	DRAWN	AKL	CHK	MR	SITE	AL-770	STRUCT	IS-770	DATE	1989

NORTH FOR CONSTRUCTION



PLAN
1:100



ELEVATION
1:100

METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
WP No 138-87-01

CNR OVERPASS
RAMP 407 EW TO 4005
TRACK PROTECTION

DILLON
Consulting Engineers • Planners
Environmental Scientists



SHEET

NOTES:

- ALTERNATIVE SHORING DESIGNS MAY BE CONSIDERED BY THE ENGINEER. ALTERNATIVE DESIGNS SHALL CONFORM TO THE FOLLOWING CRITERIA:

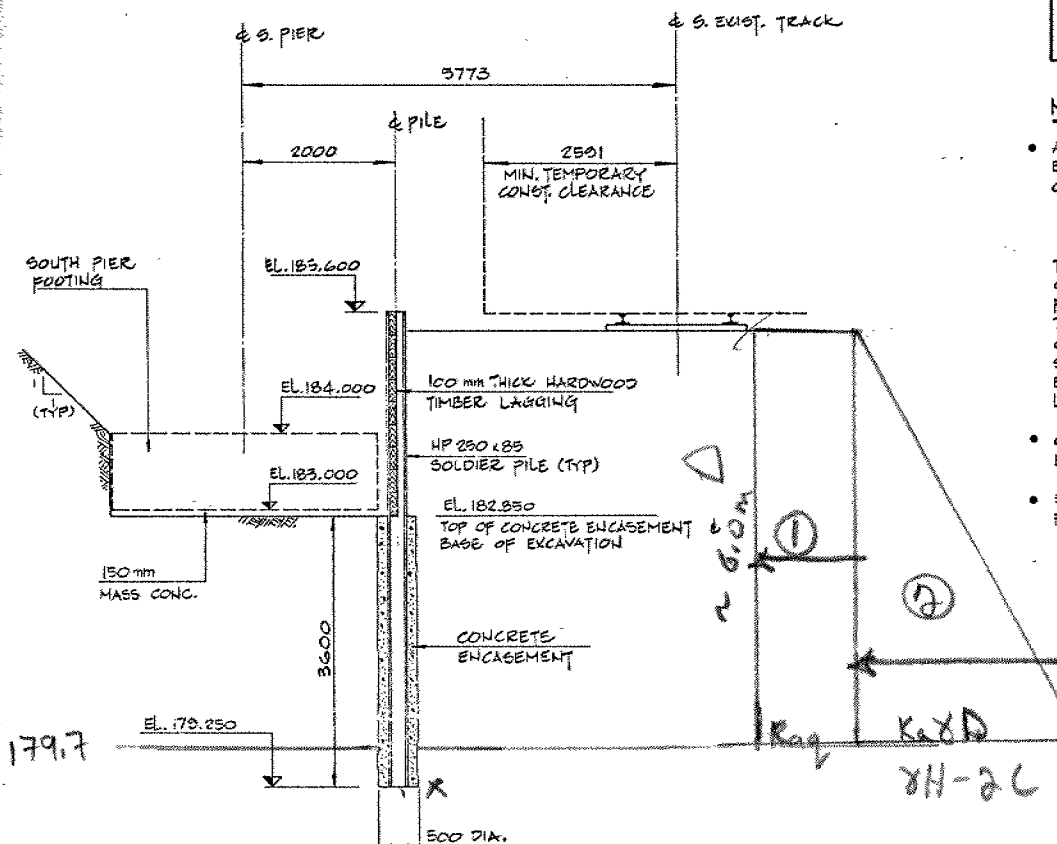
- (1) RAILROAD LIVE LOAD SURCHARGE - 2.44 m OF FILL

THE CONTRACTOR SHALL SUBMIT SIX COPIES OF CALCULATIONS AND SHOP DRAWINGS, SHOWING FULL DETAILS OF PROPOSED SHORING SYSTEM TO THE ENGINEER FOR REVIEW PRIOR TO COMMENCING WORK. ALL CALCULATIONS AND SHOP DRAWINGS SHALL BE STAMPED AND SIGNED BY A QUALIFIED PROFESSIONAL ENGINEER LICENCED IN ONTARIO.

- CLASS OF CONCRETE FOR SOLDIER PILE EMBEDMENT SHALL BE 20 MPa.

- SHORING TO BE REMOVED TO 1200 mm BELOW FINISHED GRADE PRIOR TO BACKFILLING OF FOOTING.

$$q = 2.44 \text{ m} \times 20 \frac{\text{KN}}{\text{m}^2} = 48.80 \text{ KPa}$$



$$\sum M_x = 0 = \left[K_{aq} \times D \times \frac{D}{2} + \frac{1}{2} K_a \gamma D^2 \times \frac{D}{3} \right] \times 2.5 - \left[\frac{1}{2} K_p \gamma (D-2.5)^2 \times \frac{(D-2.5)}{3} \right] (3) (1.5)$$



DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	RAR	CHK	NR
DRAWN	AXL	CHK	RAR
CODE	0900-93	LOAD	CLASS-A
DATE	FEB 89		
SITE	87-1170	STRUCT	SCHEME
DWG	3		

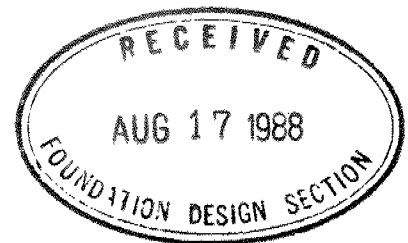


Consulting Engineers • Planners
Environmental Scientists

OUR FILE: 1798-00
YOUR FILE:

12 August 1988

Ministry of Transportation
Ontario
Foundation Design Section
Central Building
1201 Wilson Avenue
Downsview, Ontario
M3M 1J8



Att: Mr. M. Devata

CNR Overpass
Ramp 407 E.W. to 400 S.
Bridge No. 4
W.P. 138-87-~~86~~, Site 37-1170

Dear Sirs:

This will confirm our discussions with Mr. G. Al-Bazi of Structural Office on 21 July 1988, regarding the above noted structure.

The final Foundation Investigation and Design Report for Bridge No. 4, issued on 22 June 1988, recommended the provision of a 2.0m mid-height berm in the approach embankment of the above structure, in both longitudinal and transverse direction. This recommendation applies to fill heights in excess of 9m above existing grade.

Prior to our 21 July meeting, we reviewed the consequences of a 2m wide berm in the longitudinal direction, and as a result of discussions with Central Region Structural Section, the following solutions were identified:

- i) extend the structure end spans by 2m each
- ii) leave the spans as is; but extend the wing walls by 2m and lower the abutment footings

...2

DILLON

Ministry of Transportation
Ontario

- 2 -

12 August 1988

- iii) extend the end spans by 1m; extend the centre span by 2m. This, was thought, may reduce the requirement for track protection.
- iv) leave the structure as is; and reinforce the side slopes with a synthetic material. This would allow the use of 2H:1V side slopes for fills in excess of 9m.

At our 21 July 1988 meeting, it was noted that the fill height in front of the abutments is considerably less than 9m (6.8m max.). On that basis, it was agreed that a 2m wide berm in the longitudinal direction was not necessary. In the horizontal direction, however, the fill height increases along the wing walls and attains a height in excess of 9m at the tips of the wing walls. The berm, therefore, is still required in the transverse direction.

After some discussion, it was agreed that a mid-height berm starting at the front face of the abutments, and proceeding parallel to the wing walls would satisfy the stability requirements of the embankments. Slopes of 2H:1V can be maintained without reinforcement with a geo-grid material.

We have enclosed a copy of the General Arrangement drawing, indicating the location and orientation of the berm.

We trust the preceding accurately reflects our discussions. If we have misinterpreted any of your recommendations, please advise at your earliest opportunity.

Yours truly,

M. M. DILLON LIMITED



R. Radolli, P. Eng.
Project Manager

RR:gjo

cc: G. Al-Bazi, MTO
J. Lam, MTO

memorandum



To: G. Al-Bazi
Design Engineer
Structural Office

Date: 1988 07 25

From: Foundation Design Section
Room 315, Central Building

RE: General Arrangement Drawing Review
Drawing 37-117-P1
CNR Overpass Ramp 407 EW to 400 S
W.P. 138-87-~~06~~, Site 37-1170
District 6 ⁰¹ *DD*

As requested, this section has reviewed the preliminary general arrangement drawing for the aforementioned structure and the following comments are provided.

APPROACH FILLS

Approach fills in excess of 9.0 metres and at a slope of 2H:1V as illustrated in the drawing are unstable. The required stability can be obtained by:

- a) constructing a 2.0 m midheight berm both in the longitudinal and transverse directions as recommended in the original foundation investigation report.

or

- b) using Geogrid reinforced earth with 2H:1V side and forward slopes as advised in our letter dated 1988 07 13 addressed to Mr. G.C.E. Burkhardt (see attached letter).

STRUCTURE FOUNDATIONS

The structure foundations chosen comply to the recommendations provided in the foundation report. The concrete working slab, however, should be placed as readily as possible (within 4 hours of exposure) rather than 8 hours to protect the founding soil from the effects of weathering.

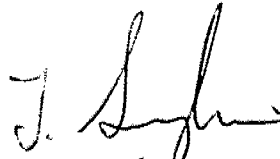
TRACK PROTECTION

The temporary shoring system required during the excavation of the south pier is to be designed to resist all applicable pressures. The extent of the shoring appears to be adequate and acceptable. A further review of the shoring system will be implemented when details of the shoring are provided.

ADDITIONAL LOADINGS ON FORCEMAINS

The additional loadings on the forcemains was addressed by this section in a memorandum addressed to Mr. G.C.E. Burkhardt dated 1988 06 13 (see attached letter). The field supporting strength of the pipe should be compared to the additional stresses induced to ensure that an adequate safety factor against bending and rupture exists.

If you have any queries regarding the above review or require further information, please do not hesitate to contact this office.



T. Sangiuliano, P. Eng.,
Foundations Engineer

TS/mj

Attach.

memorandum



To: G.C.E. Burkhardt
Head, Structural Section
5000 Yonge Street

Date: 1988 07 13

Atten: J. Lam, Sr. Structural Engineer

From: Foundation Design Section
Room 315, Central Building

RE: Approach Fills to
Ramp Structure 407 EW to 400 S

As per our discussions, this letter confirms that Geogrid reinforced earth with 2H:1V side and forward slopes can be used as an alternative to the 2 m berm originally recommended in the foundation report for the aforementioned structure. Information pertaining to the design, construction, monitoring and overall costs are summarized in the attached paper prepared by M. Devata, P. Eng. Chief Foundation Engineer of this Section.

If further information is required, please do not hesitate to contact this office.

A handwritten signature in black ink, appearing to read "T. Sangiuliano".

T. Sangiuliano, P. Eng.
Foundation Engineer

TS/mmj

Attach.

memorandum



To: G.C.E. Burkhardt
Head
Structural Section
Central Region, Toronto

Date: 1988 06 13

Attn: J. Lam
Senior Structural Engineer

From: Foundation Design Section
Room 315, Central Building

RE: W.P. 138-87-⁰¹~~06~~
Ramp 407 E,W to 400S
Additional Loadings on Forcemains

As requested in your memo dated 1988 06 06, an evaluation of the impact on the two 600 mm forcemains as a result of the abutment and approach ramp loadings for the proposed aforementioned structure has been completed by this office. The location and elevation of the forcemains were obtained from the Sewer and Forcemain drawing 1133-R0004(2) and preliminary general arrangement drawing dated May 26, 1988. The following comments are provided:

1) Abutment Loadings

The abutment loading (combined live load and dead load) will not induce any additional vertical or horizontal stresses on the forcemains with the proposed arrangement.

2) Approach Ramp Loading

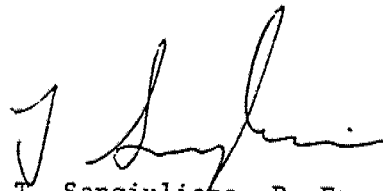
Additional stresses will be induced as a result of the placement of upto 11 m of approach fills in advance of the north abutment. The additional vertical load developed can be calculated by assuming a unit weight of the fill (γ Fill) of 22.0 KN/m³. The stresses at the forcemain elevation can be assumed to be equal to surface loading. Horizontal stresses can be calculated using the at rest coefficient of lateral earth pressure of 0.5. The embankment loading will have its greatest influence along its centre line in the longitudinal direction. The native soil can be considered as unyielding and consequently no settlements are anticipated.

Repeated axial stresses induced by highway traffic will have dissipated before reaching the forcemain elevation and consequently these dynamic loadings will not have any influence on the forcemains.

The factor of safety against excessive bending-moment stresses and pipe wall rupture should be determined as a result of the additional loadings. Determination of the field supporting strength which is

dependent on the shape, size and material properties of the forcemain, the bedding class, load factors and internal pressures is required. If this factor of safety proves to be inadequate, both geotechnical and structural recommendations for improvement can then be discussed in detail.

If further assistance is required, please do not hesitate to contact this office.

A handwritten signature in cursive script, appearing to read 'T. Sangiuliano', is written above the printed name.

T. Sangiuliano, P. Eng.
Foundations Engineer

TS/mj

memorandum

235-3731



To: Mr. G.C.E. Burkhardt
Head, Structural Section
Central Region, Toronto

Date: 1988 03 03

From: Foundation Design Section
Room 315, Central Building

RE: FOUNDATION INVESTIGATION For
RAMP STRUCTURE 407 E, W to 400 S
(OVER C.N.R.) BRIDGE #4
W.P. 138-87-06
DISTRICT #6. TORONTO

The following provides the results of the initial phase of our Foundation Investigation implemented at the aforementioned site. This initial segment of the investigation was restricted to areas of the site beyond the CNR property. Subsurface conditions and pertinent recommendations regarding structure foundations and related earthworks are provided for both the areas beyond and within the CNR property. However, it should be cautioned that the recommendations provided are based on extrapolation of the existing boreholes and are intended for preliminary use only. Subsequent investigation within the CNR right of way may alter the recommendations. The final report will be forwarded upon completion of the second phase of the investigation which presently is on hold until permission is obtained to enter into CNR property as you were previously advised in our memorandum dated 1988 01 13. If further information is required, please contact this office.

.../2

SUBSURFACE CONDITIONS

Four sampled boreholes accompanied by dynamic cone penetration tests were advanced in the proximity of the proposed four retaining walls. Sampling was performed to a maximum depth of 15.7 m corresponding to an elevation of 171.1 m.

The surficial deposit consists of a silt/clayey silt with/some sand, trace of gravel. The deposit is of glacial origin and extends to a depth of 8.0 m. This cohesive stratum has a compact to very dense/stiff to hard consistency. Underlying the surficial deposit is a silt layer with sand with a thickness up to 2.0 metres. This layer has a denseness ranging from compact to very dense. A second deposit of glacial till underlies the silt deposit and consists of a silt/clayey silt of very dense/hard consistency.

Groundwater levels stabilized at elevations ranging from 186.1 metres to 185.8 metres or approximate depths of 0.5 metres to 1.0 metres from ground surface.

RECOMMENDATIONS

A three span ramp structure is proposed to carry Hwy 407 E, W traffic over the CNR tracks and onto Hwy 400 S. The 20 m wide bridge deck will be set at a sloping elevation ranging between 197 m and 198 m.

The following are preliminary recommendations regarding:

- 1) structure foundations and related earthworks
- 2) temporary shoring of CNR tracks
- 3) lateral earth pressures on abutments/retaining walls
- 4) approach fills

STRUCTURE FOUNDATIONS

The proposed structure may be founded on spread footings in the upper silt/clayey silt deposit or steel H-piles driven to the lower silt/clayey silt deposit. Major consideration should be given to supporting the retaining walls/abutments on compacted Granular 'A' Fill. The alternative, or combination, which leads to the least expensive design is recommended.

1) Spread Footings

The proposed structure may be supported on spread footings founded within the upper silt/clayey silt deposit. For purposes of the O.H.B.D.C., the following design values are recommended:

<u>Structure</u>	<u>Elevation</u>	<u>Bearing Capacity at S.L.S. Type II</u>	<u>Factored Bearing Capacity at U.L.S</u>
Retaining Walls	≤183 m	350 kPa	525 kPa
Abutments	≤183 m	350 kPa	525 kPa
Piers	≤181 m	350 kPa	525 kPa

The underside of all footings should be provided with a minimum 1.25 metres of earth cover for frost protection.

Sliding resistance can be calculated by assuming an adhesion of 75 kPa between the underside of the rough concrete footing and the soil.

No major dewatering difficulties are anticipated for footing excavations in consideration of the relatively low permeability of the glacial till deposit. A concrete working slab should be placed to protect the footing founding soil against weathering within 8 hours of exposure.

In view of the overconsolidated nature of the founding soil, settlements will be minimal and should not exceed 25 mm.

Alternatively, the abutments/retaining walls can be supported on spread footings perched within compacted Granular 'A' fill as illustrated in the attached Figure No. 1. All surficial softened and/or organic material within the planned limits of the granular core must be subexcavated prior to its placement. The following design values are recommended:

Factored Capacity at U.L.S.	900 kPa
Allowable Capacity at S.L.S. Type II	350 kPa

Sliding resistance may be computed by assuming a coefficient of friction of 0.7 between the underside of the rough concrete footing and the Granular 'A' core.

Settlements should be minimal and should not exceed 25 mm.

2) Steel H-Piles

The structure foundations can be founded on deep foundation units driven to end bearing in the lower very dense/hard silt/clayey silt. For a steel 'H' section pile equipped with standard reinforced flange tip plates and driven to a minimum set of 15 blows per 25 mm for all the final 75 mm of placement using a minimum rated driving energy of 48,000 joules/blows, the following design parameters are suggested:

<u>File Type</u>	Capacity at <u>S.L.S. Type II</u>	Factored Capacity <u>at U.L.S.</u>
310 HP 79	800 kN	1250 kN
310 HP 110	1000 kN	1600 kN

For design estimating purposes, theoretical pile embedment lengths can be calculated assuming anticipated tip elevations of 174 metres.

Abutment pile caps may be perched within the embankment fill provided that particle sizes in the fill immediately beneath the pile locations does not exceed 75 mm.

Resistance to lateral load shall be computed in accordance with Section 6.8.3.8 of the O.H.B.D.C.

Total and differential settlements will be negligible.

Temporary Shoring

Depending on the proximity of the pier footings to the CNR rails, a temporary shoring system may be required to protect the rail

supporting soil during construction. It is recommended that the shoring system be in the form of a sheet pile wall or a soldier pile - lagging wall. Earth pressures against the temporary wall should be computed as per Subsection 6.6.1.2.1 of the O.H.B.D.C. Manual.

LATERAL EARTH PRESSURES ON ABUTMENTS/RETAINING WALLS

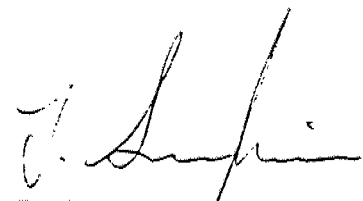
Backfill to abutments and retaining walls should consist of Granular 'A' or Granular 'B' for which the following properties are recommended:

Granular 'A'	= 22.8 kN/m ³	$\phi = 35^\circ$	$K_A = 0.27$
Granular 'B'	= 21.2 kN/m ³	$\phi = 30^\circ$	$K_A = 0.33$

Lateral pressures should be computed in accordance with Section 6.6.1.2.1 of the code. A yielding foundation condition may be assumed.

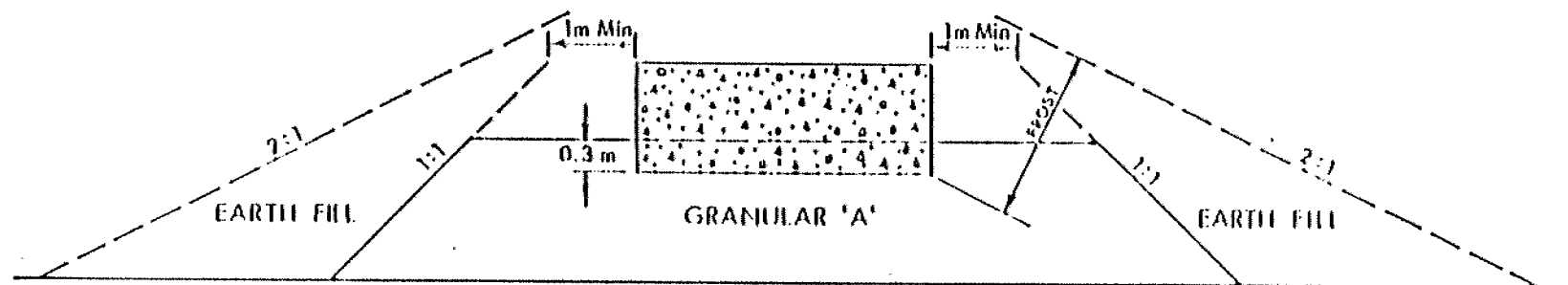
APPROACH FILLS

Approach fills up to an order of magnitude of 10.0 m will be required. No stability problems are anticipated for approach fills constructed with 2H:1V slopes. The fill should be well compacted. No significant settlements are anticipated.

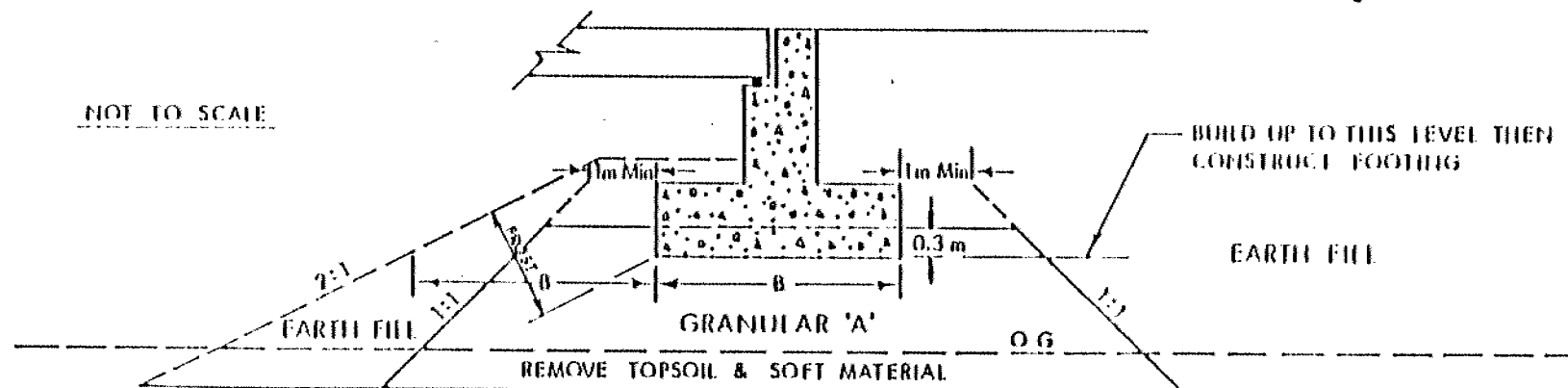


T. Sanguiliano

Foundation Engineer



X SECTION



LONGITUDINAL SECTION

NOTES:

- 1 - REMOVE TOPSOIL &/OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' & EARTH FILL.
- 2 - PLACE GRANULAR 'A' & EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO CURRENT M T C STANDARDS.
- 3 - CONSTRUCT CONCRETE FOOTING.
- 4 - PLACE REMAINDER OF GRANULAR 'A' & EARTH FILL AS REQUIRED.



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ABUTMENT ON COMPACTED FILL
SHOWING GRANULAR 'A' CORE

FIG No 1

W P 138-87-06