

REMARKS: _____

FOUNDATION INVESTIGATION REPORT

CONTRACT NO 91-07



Ontario

Ministry of
Transportation and
Communications

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Note: For purposes of the contract, this report supersedes all other Foundation Reports prepared by, or for the Ministry in connection with the above mentioned project.

EXPLANATION OF TERMS USED IN REPORT

2

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'_{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_t	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^2	SEEPAGE FORCE
γ'	KN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

FOUNDATION INVESTIGATION REPORT
For
Kettle Creek Structure Replacement
W.P. 73-85-01; Str. Site 5-30
Highway 73, District 2, London

INTRODUCTION

This report contains the results of a Foundation Investigation carried out for the proposed structure replacement and detour at the above location. The fieldwork was carried out from 89-03-20 to 89-03-22. The fieldwork consisted of four sampled boreholes and 6 dynamic cone penetration tests, four of which were adjacent to the boreholes. The borings were advanced by hollow and solid stem augers (57 mm I.D. and 121 mm O.D. respectively), using a machine mounted on a truck.

Sampling was performed to a maximum depth of 12.6 m to elevation 252.9 and the cone tests to a maximum depth of 6.5 m to elevation 258.9.

SITE DESCRIPTION

The site is located approximately 2 km south of Harrietsville on Highway 73 in the Township of South Dorchester. The physiography is undrumlinized Till Plains. At the site Kettle Creek follows a glacial drainage channel to the north of the St. Thomas moraine. This channel is lined with silt and to a less extent with sand and gravel deposits. The land use in the immediate vicinity is agricultural and the terrain is rolling.

SUBSURFACE CONDITIONS

General

The subsoil was found to consist of a heterogeneous mixture of clayey silt, sand and gravel till with occasional zones of sandy silt. This deposit extended from the bottom of the fill along the road to under the 0.6 to 0.9 m of topsoil found off the road to the end of the sampled boreholes. The fill material at the site consisted of (shoulder material) gravelly sand, trace of silt, trace of clay.

The plan and location of boring and the stratigraphical profile are shown on Drawing 738501-A* in the attached Appendix. The field and laboratory test results are plotted on the Record of Borehole sheets also in the Appendix of this report. A brief description of the different soil types is given below.

Gravelly Sand (Fill)

This material was found from the road surface (shoulder) to the top of the Heterogeneous mixture of clayey silt, sand and gravel at elevation 263± to a depth of 2.5± m. The fill consisted of gravelly sand trace of silt, trace of clay with occasional cobbles.

The natural moisture content (w) of the fill as determined by a laboratory test was 5.5%. The grain size distribution test indicated 42% gravel, 49.5% sand and 8.5% silt and clay. The denseness of the material was compact.

Heterogeneous Mixture of Clayey Silt, Sand and Gravel

The main deposit is a glacial deposit consisting of a heterogeneous mixture of clayey silt, sand and gravel with zones of sandy silt. This deposit was found beneath the surficial material off the road at elevation 263± and beneath the fill under the shoulders to the end of the borings.

The physical properties of the cohesive material as determined by the field and laboratory tests are as follows:

	<u>Range</u>
Natural Moisture Content (w)	8-23%
Liquid Limit (w_L)	20-43.5%
Plastic Limit (w_p)	10-16.5%

The N-blows from the standard penetration tests averaged at 69, ranging from 17 to 145, tending to become harder with depth. One test indicated a values of 4 at top of layer under the fill. Based on these values the consistency of the material ranged from very stiff to hard. The grain size distribution is shown

* DWG NO 2 OF THE CONTRACT DWG'S

on Figure 1 in envelope form. Figure 2 indicates that the majority of the material was a clayey silt (of low plasticity), with some of intermediate plasticity (silty clay).

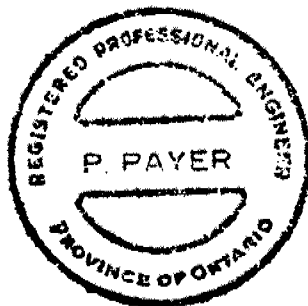
Within this material, zones of approximately 1 m± thick were found of non-cohesive sandy silt. The natural moisture content of the sandy silt was 19%. The grain size distribution tests indicated 1 to 12% sand and 88 to 99% silt and clay.

GROUNDWATER CONDITIONS

Due to the short duration of the field investigation, no stabilized water levels were obtained with the probable exception of Borehole 4. The water level in Borehole 4 was 2.2 m below the ground surface at approximate elevation 261.5 m. The groundwater level will most likely vary seasonally and with the level in the creek. On 88-10-27 the water level in the creek was at elevation 263.3 m, and on 85-04-04, at elevation 261.7 m.

MISCELLANEOUS

The fieldwork for this investigation was carried out by Mr. P. Dubé, Trainee Engineer. The fieldwork was carried out under the supervision of Mrs. P. Marks, Foundation Engineer, who also prepared this report. The equipment used for the field investigation was owned and operated by London Soil. The entire project was carried out under the general supervision of Mr. P. Payer, Senior Foundation Engineer. The report was reviewed by M. Devata, Chief Foundation Engineer.



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APPENDIX

RECORD OF BOREHOLE No 1

METRIC

W P 73-85-01 LOCATION Station: 17 + 361.8, offset 5.1 m L.L. of 4
 DIST 2 HWY 73 BOREHOLE TYPE Continuous Flight Auger (H.S.) & Cone Test
 DATUM Geodetic DATE 89 03 20
 ORIGINATED BY PD
 COMPILED BY PM
 CHECKED BY M

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT		UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20 40 60 80 100		W _p W W _L			
265.5	Road Surface											
0.0	Gravelly Sand Trace of Silt Occ. Cobbles (Fill)		1	SS	10							
			2	SS	13							
262.9	Compact		3	SS	10							
2.6			4	SS	4							
	Heterogeneous Mixture of Clayey Silt Sand and Gravel		5	SS	51							
			6	SS	52							
			7	SS	39							
			8	SS	47							
	with Zones of Sandy Silt (Glacial Till)		9	SS	82							
			10	SS	86							
			11	SS	136							
			12	SS	102							
	Hard		13	SS	118							
252.9			14	SS	83							
12.6	End of Borehole											
	* Water level not Established											

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 2

METRIC

W P 73-85-01 LOCATION Station: 17 + 343.6; offset 5.6 Rt. of E ORIGINATED BY PD
 DIST 2 HWY 73 BOREHOLE TYPE Continuous Flight Auger (H.S.) & Cone Test COMPILED BY PM
 DATUM Geodetic DATE 89.03.20 to 21 CHECKED BY [Signature]

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						
265.5	Road Surface													
0.0	Gravelly Sand Trace of Silt Trace of Clay		1	SS	16		264	Pre-augered						
263.0	(Fill) Compact		2	SS	14									
2.5			3	SS	11	*								
			4	SS	17		262							26 43 23 8
			5	SS	100/	15 cm								2 5 (93)
			6	SS	120			120 / 15 cm						60 13 (27)
	Heterogeneous Mixture of Clayey Silt Sand and Gravel		7	SS	135		260							
			8	SS	140									
	with Zones of Sandy Silt		9	SS	39		258							0 1 (99)
	(Glacial Till)		10	SS	105									
			11	SS	220/	25 cm								0 12 (88)
	Hard		12	SS	59		256							
			13	SS	145		254							
252.9			14	SS	136									0 1 (99)
12.6	End of Borehole													
	* Water level not Established													

+3, x5: Numbers refer to Sensitivity
 20
 15 5 (%) STRAIN AT FAILURE
 10

RECORD OF BOREHOLE No 3

METRIC

W P 73-85-01 LOCATION Station: 17 + 330.7; offset 25.4 m Rt. of C ORIGINATED BY PD
 DIST 2 HWY 73 BOREHOLE TYPE Continuous Flight Auger (S.S.) & Cone Test COMPILED BY PM
 DATUM Geodetic DATE 89 03 21 CHECKED BY M

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	W _p	W	W _L		
265.1	Ground Surface												GR SA SI CL
0.0 264.5	Topsoil												
0.6	Heterogeneous Mixture of Clayey Silt Sand, Gravel (Glacial Till)		1	SS	20	*	264	Pre-augered					5 11 (84)
			2	SS	51								
			3	SS	41								
			4	SS	28		262	120 / 25 cm					
			5	SS	86								15 30 (55)
260.1	Very Stiff to Hard		6	SS	116								14 17 (69)
5.0	End of Borehole												
	*Water level not Established												

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4

METRIC

W P 73-85-01 LOCATION Station: 17 + 357.1; offset 24.8 Rt. of 4 ORIGINATED BY PD
 DIST 2 HWY 73 BOREHOLE TYPE Continuous Flight Auger (S.S.) & Cone Test COMPILED BY PM
 DATUM Geodetic DATE 89 03 22 CHECKED BY M

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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES							
263.7	Ground Surface											
0.0	Topsoil											
262.8												
0.9	Heterogeneous Mixture of Clayey Silt, Sand and Gravel		1	SS	8							
			2	SS	34							
			3	SS	24							
			4	SS	41							
	(Glacial Till)		5	SS	38							
258.7	Hard		6	SS	79							
5.0	End of Borehole											

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 5

METRIC

W P 73-85-01 LOCATION Station: 17 + 358.9; offset 5.2 m Rt. of ORIGINATED BY PD
 DIST 2 HWY 73 BOREHOLE TYPE Cone Penetration Test COMPILED BY PM
 DATUM Geodetic DATE 89 03 21 CHECKED BY th

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	'N' VALUES								
265.5	Road Surface												
0.0	Presumed Gravelly Sand												
	(Fill)												
	Presumed Het. Mixture of Clayey Silt Sand and Gravel												
261.5													
4.0	End of Cone Test												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 6

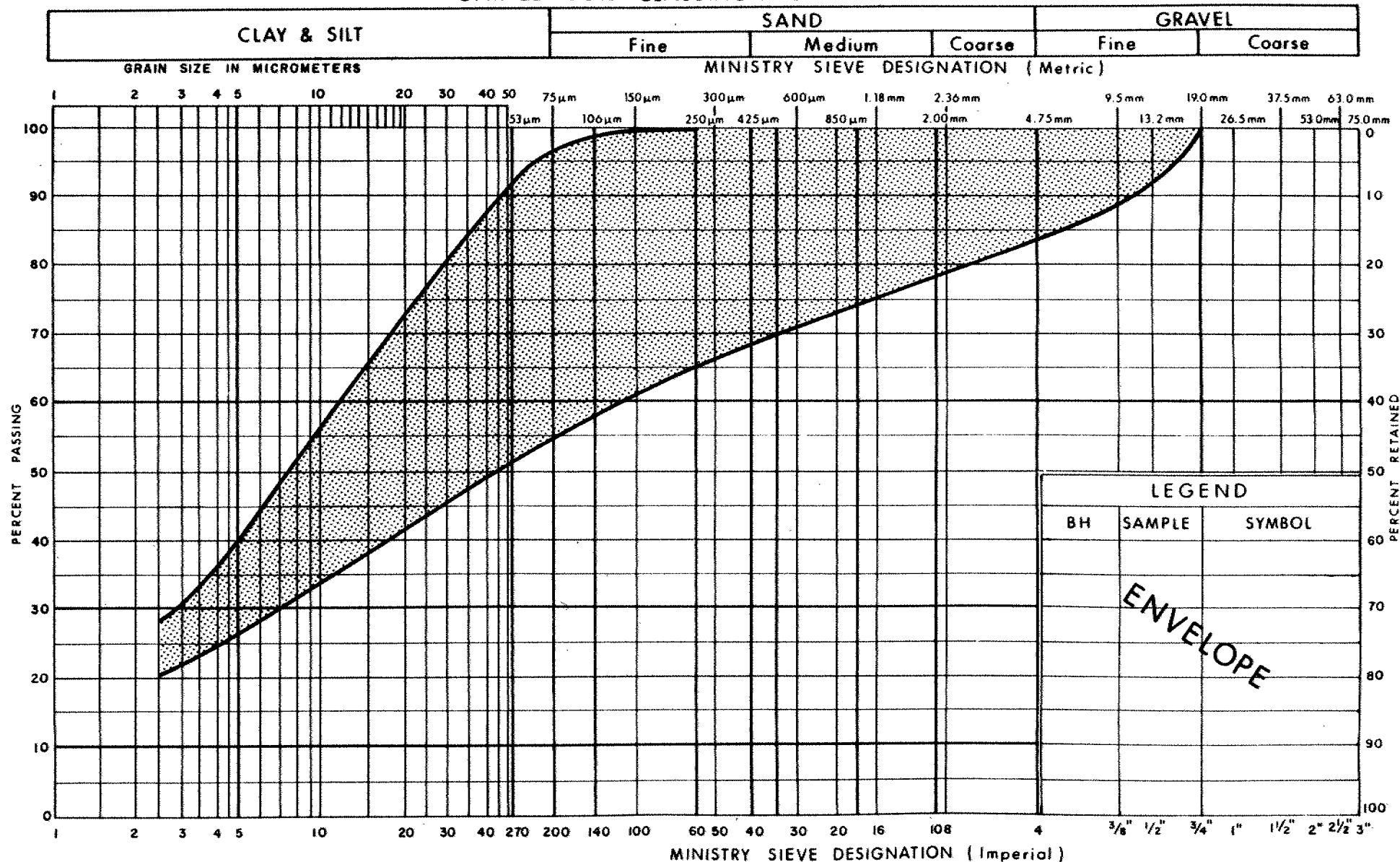
METRIC

W P 73-85-01 LOCATION Station: 17 + 344.8; offset 4.9 m Lt. of E ORIGINATED BY PD
 DIST 2 HWY 73 BOREHOLE TYPE Cone Penetration Test COMPILED BY PM
 DATUM Geodetic DATE 89 03 21 CHECKED BY MM

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								
265.5	Road Surface												
0.0	Presumed Gravelly Sand												
	(Fill)												
	Presumed Het. Mixture of Clayey Silt Sand and Gravel												
261.0													
4.5	End of Cone Test												

OFFICE REPORT ON SOIL EXPLORATION

UNIFIED SOIL CLASSIFICATION SYSTEM

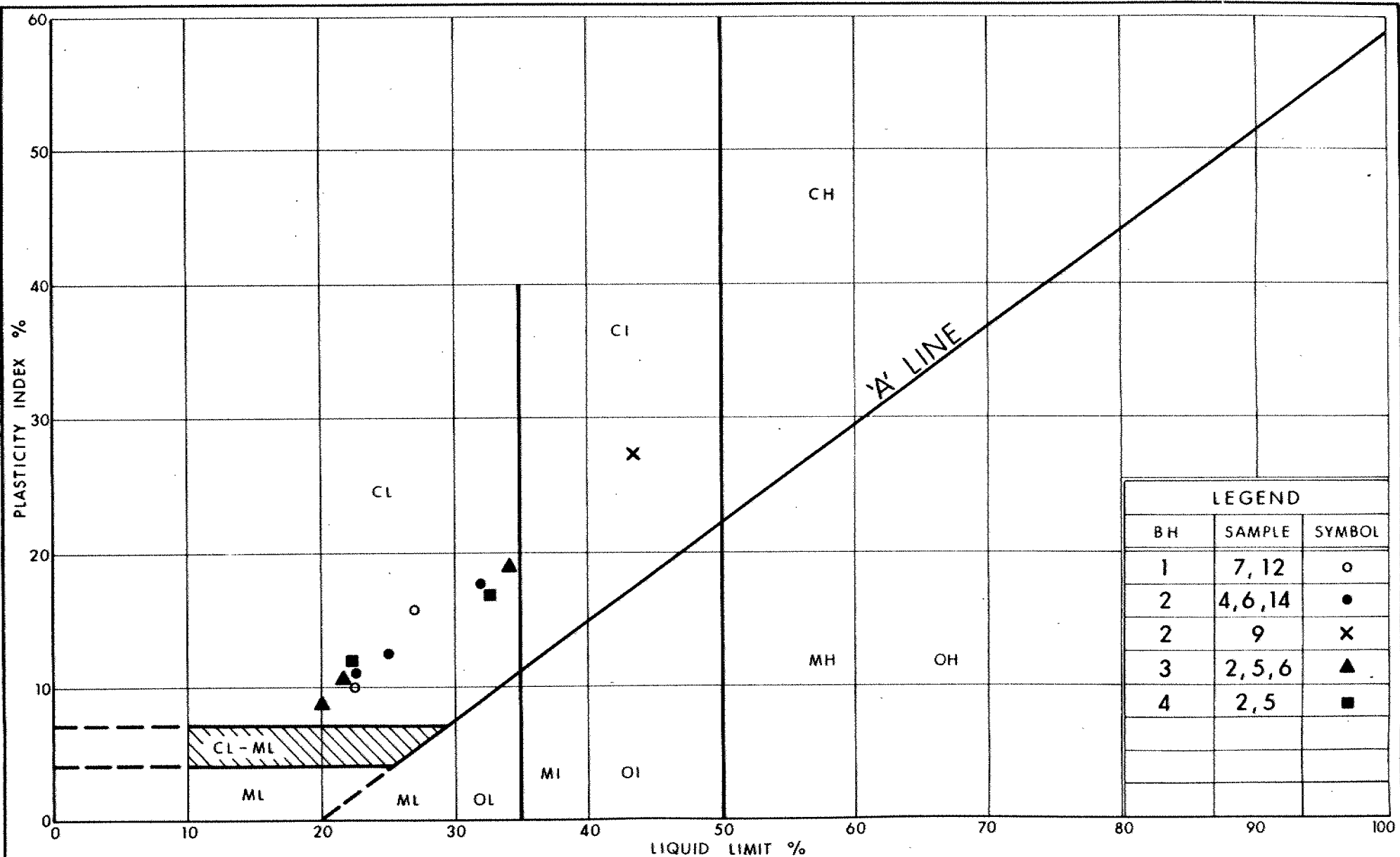


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Transportation

GRAIN SIZE DISTRIBUTION
HET MIXTURE OF
CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 1

W P 73-85-01



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Ontario

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

FIG No 2

W P 73-85-01

FOUNDATION INVESTIGATION REPORT
For
West Catfish Creek Structure Replacement
W.P. 73-85-02; Str. Site 5-29
Highway 73, District 2, London

INTRODUCTION

This report contains the results of a Foundation Investigation carried out for the proposed structure replacement and detour at the above location. The fieldwork was carried out from 89-03-21 to 89-03-30. The fieldwork consisted of four sampled boreholes and 6 dynamic cone penetration tests of which 4 were adjacent to the boreholes. The borings were advanced by hollow and solid stem augers (57 mm I.D. and 121 mm O.D. respectively), and BX casing (60 mm I.D.), using a machine mounted on a truck.

Sampling was performed to a maximum depth of 27.3 m to elevation 238.9 and the cone tests to a maximum depth of 4.5 m to elevation 261.7 m.

SITE DESCRIPTION

The site is located approximately 2 km north of Lyons on Highway 73 in the Township of South Dorchester. West Catfish Creek lies in a spillway separating the St. Thomas and Norwich till moraine's. The land use in the immediate vicinity is agricultural and the terrain is relatively flat at the site.

SUBSURFACE CONDITIONS

General

The subsoil was found to consist of a heterogeneous mixture of clayey silt, sand and gravel. This deposit extended from the bottom of the fill or beneath the surficial material to the end of the sampled boreholes and in borehole 1 to the sandy silt at elevation 240.6 m (25.6m below the surface). The sandy silt was encountered to the end of sampling of borehole 1. Although no sampling was carried out off the road along the proposed detours, surficial material is likely to consist of 0.6 to 1.0 m of topsoil.

The plan and location of borings and the stratigraphical profile are shown on Drawing 738502-A* in the attached Appendix. The obtained field and laboratory test results are plotted on the Record of Borehole sheets also in the Appendix of this report. A brief description of the different soil types is given below:

Gravelly Sand (Fill)

This material was found from the road surface (shoulder) to the top of the Heterogeneous mixture of clayey silt, sand and gravel at elevation 265.9 in borehole 4 to 264.2 in borehole 2. The material ranged in thickness from 0.8± m to 2.1± m. The fill consisted of gravelly sand, trace of silt, trace of clay.

The natural moisture content (w) of the fill as determined by a laboratory test was 4.5%. The grain size distribution test indicated 26% gravel, 62% sand, 9% silt and 3% clay. The denseness of the material ranged from loose to compact.

Heterogeneous Mixture of Clayey Silt, Sand and Gravel

The main deposit is a glacial deposit consisting of a heterogeneous mixture of clayey silt, sand and gravel. This deposit was found beneath the surficial material off the road and under the fill along the road to the end of sampling excluding borehole 1 where sandy silt was encountered at elevation 240.6± m.

The physical properties of the material as determined by the field and laboratory tests are as follows:

	<u>Range</u>
Natural Moisture Content (w)	10-27%
Liquid Limit (w_L)	24.5-38.5%
Plastic Limit (w_p)	12.5-22%

The N-blows from the standard penetration tests averaged at 30, ranging from 11 to 55 with occasional tests indicating over a hundred at the end of the deep boreholes. Based on these values the consistency of the glacial till ranged

* DWG NO 2 OF THE CONTRACT DWG'S

from stiff to hard. The grain size distribution is shown on Figure 1 in envelope form. Figure 2 indicates that the majority of the material plots as a clayey silt of low plasticity with one test indicating a silty clay of intermediate plasticity.

Sandy Silt

Beneath the heterogeneous mixture at approximate elevation 240.6 m in borehole 1 a deposit of sandy silt of low plasticity was found to the end of the borehole. A laboratory test indicated that the natural moisture content (w) was 14%, liquid limit (w_L) 13.5%, plastic limit (w_p) 12.5%. Plotted on the plasticity chart this indicates a silt of low plasticity (ML). The grain size distribution test shows no gravel, 11% sand and 89% silt and clay.

GROUNDWATER CONDITIONS

Due to the short duration of the field investigation, no stabilized water levels were taken with the exception of borehole 1. Borehole 1 indicated the groundwater level to be about 2.1 below the road at approximate elevation 264.1 m. The following creek water levels have been recorded:

October 27, 1988	263.3
March, 1989	264.1
April 4, 1989	263.5

The groundwater level will most likely vary seasonally and with the level in the creek.

MISCELLANEOUS

The fieldwork for this investigation was carried out by Mr. P. Dubé, Trainee Engineer. The fieldwork was carried out under the supervision of Mrs. P. Marks, Foundation Engineer, who also prepared this report. The equipment used for the field investigation was owned and operated by London Soil. The entire project was carried out under the general supervision of Mr. P. Payer, Senior Foundation Engineer. The report was reviewed by M. Devata, Chief Foundation Engineer.



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APPENDIX

RECORD OF BOREHOLE No 1

METRIC

W P 73-85-02 LOCATION Station: 14 + 788.4; offset S.3 Rt. of E ORIGINATED BY PD
 DIST 2 HWY 73 BOREHOLE TYPE Continuous Flight Auger (S.S.); BX Casing & Cone COMPILED BY PM
 DATUM Geodetic DATE 89 03 21 to 23 Test CHECKED BY JM

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			
266.2	Road Surface														
0.0	Gravelly Sand, Trace Silt, Trace Clay (Fill)		1	SS	16		266								
264.6	Compact		2	SS	6		264								7 18 61 14
1.6	Trace of Organics		3	SS	14										
			4	SS	42										
			5	SS	42										
			6	SS	33										3 6 (91)
			7	SS	34										
			8	SS	26										
			9	SS	25										1 5 (94)
			10	SS	30										
			11	SS	28										
			12	SS	20										3 6 (91)
			13	SS	22										
			14	SS	20										
	Heterogeneous Mixture of Clayey Silt		15	SS	18										
	Sand and Gravel		16	SS	22										
	(Glacial Till)		17	SS	13										
			18	SS	46										2 5 (93)
			19	SS	39										
			20	SS	100/15 cm										
240.6	Stiff / Hard						240								
25.6	Sandy Silt Very Dense														
238.9			21	SS	99										0 12 (88)
27.3	End of Borehole														

+3, x5: Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 2

METRIC

W P 73-85-02 LOCATION Station: 14 + 770.7; offset 5.3 Lt. of ORIGINATED BY PD
 DIST 2 HWY 73 BOREHOLE TYPE Continuous Flight Auger (H.S.) & Cone Test COMPILED BY PM
 DATUM Geodetic DATE 89 03 28 to 29 CHECKED BY ME

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 Wp NATURAL MOISTURE CONTENT W LIQUID LIMIT Wl	WATER CONTENT (%) 10 20 30	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
266.3	Road Surface												
0.0	Gravelly Sand												
	Trace Silt												
	Trace Clay (Fill)												
264.2	Loose		1	SS	8		266						26 62 9 3
			2	SS	6								
2.1	Trace of Organics		3	SS	5		264						
			4	SS	42								
			5	SS	41								
			6	SS	37		262	120 / 25 cm					
			7	SS	33								0 6 (94)
			8	SS	22		260						
			9	SS	26								
			10	SS	16		258						
			11	SS	21								
			12	SS	23								
			13	SS	18		256						
			14	SS	14								
	Heterogeneous Mixture of Clayey Silt		15	SS	28		254						
	Sand and Gravel		16	SS	33		252						
	(Glacial Till)		17	SS	45		250						
	Stiff to Hard		18	SS	40		248						
			19	SS	55		246						
			20	SS	100/13 cm		244						13 19 44 24
239.9			21	SS	100/15 cm		242						
26.4	End of Borehole						240						
	* Water level not Established												

+3, x5: Numbers refer to Sensitivity
 20
 15
 10
 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 3

METRIC

W P 73-85-02 LOCATION Station: 14 + 788.1; offset 24.8 m Lt. of
 DIST 2 HWY 73 BOREHOLE TYPE Continuous Flight Auger (S.S.) & Cone Test
 DATUM Geodetic DATE 89 03 29
 ORIGINATED BY PD
 COMPILED BY PM
 CHECKED BY MM

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	SHEAR STRENGTH k_p	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									
265.3	Ground Surface												
0.0	Trace of Organics		1	SS	13								
	Heterogeneous Mixture of Clayey Silt Sand and Gravel		2	SS	21								
	(Glacial Till)		3	SS	52								
			4	SS	36								
			5	SG	35								
260.3	Stiff to Hard		6	SS	34								
5.0	End of Borehole												
	* Water level not Established												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 4

METRIC

W P 73-85-02 LOCATION Station: 14 + 732.0; offset 5.3 m Lt. of E ORIGINATED BY PD
 DIST 2 HWY 73 BOREHOLE TYPE Continuous Flight Auger (H.S.) & Cone Test COMPILED BY PM
 DATUM Geodetic DATE 89 03 30 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	WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE								
266.7	Road Surface											
0.0	Gravelly Sand, Trace Silt, Trace Clay (Fill) Loose		1	SS	13							
265.9			2	SS	11							
0.8	Heterogeneous Mixture of Clayey Silt Sand and Gravel (Glacial Till)		3	SS	17							
			4	SS	44							
			5	SS	38							
261.7	Stiff to Hard		6	SS	50							
5.0	End of Borehole											
	* Water level not Established											

OFFICE REPORT ON SOIL EXPLORATION


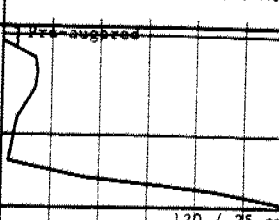
+³, x⁵: Numbers refer to Sensitivity

20
15
10
5
0
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 5

METRIC

W P 73-85-02 LOCATION Station: 14 + 789.0; offset 4.9 m Lt. of E ORIGINATED BY PD
 DIST 2 HWY 73 BOREHOLE TYPE Cone Penetration Test COMPILED BY PM
 DATUM Geodetic DATE 89 03 30 CHECKED BY M

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								
266.2	Road Surface					266						
0.0	Presumed Gravelly Sand											
	(Fill)											
262.6	Presumed Het. Mixture of Clayey Silt Sand and Gravel					264						
3.6	End of Cone Test											

OFFICE REPORT ON SOIL EXPLORATION


+3, x5: Numbers refer to Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 6

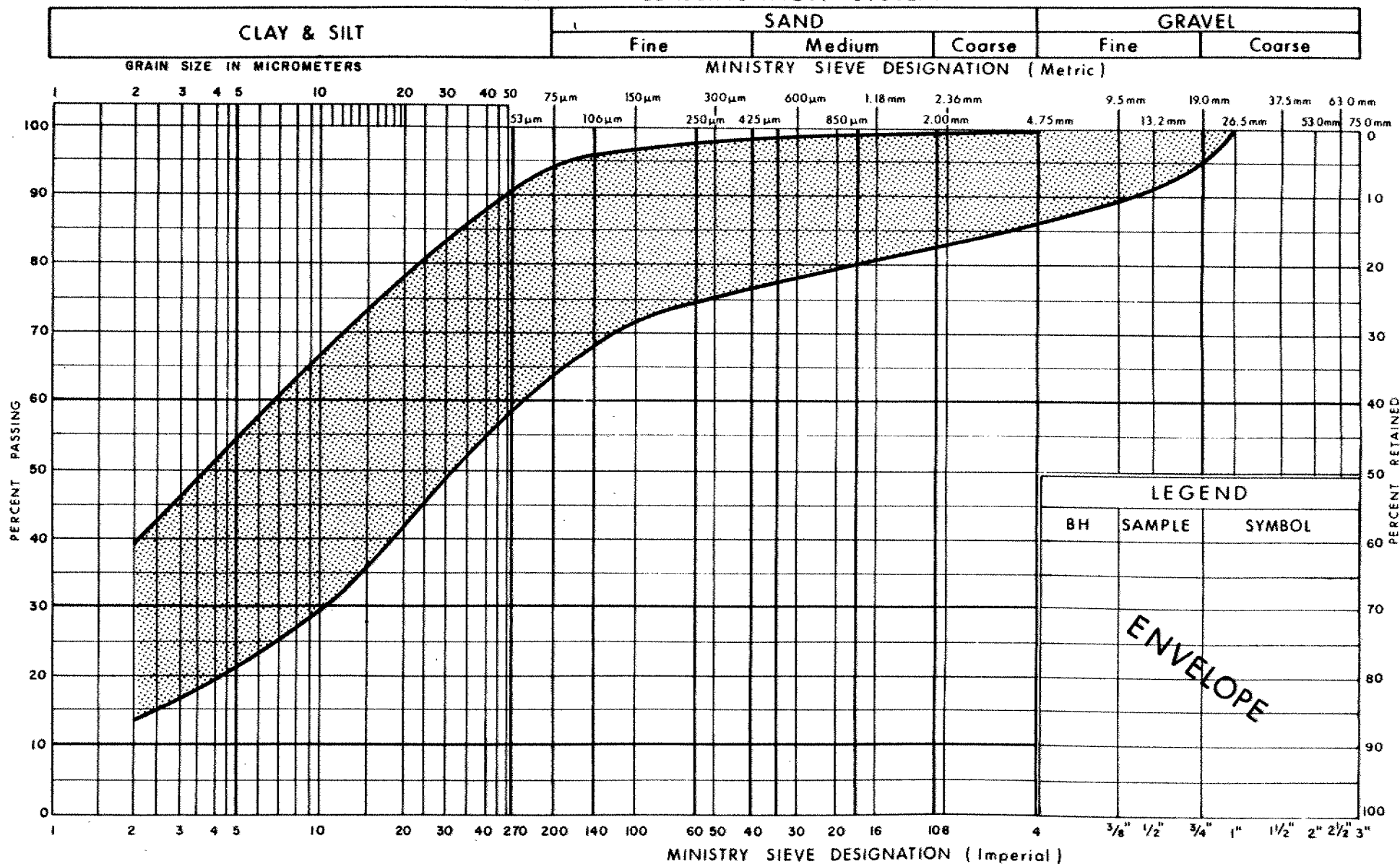
METRIC

W P 73-85-02 LOCATION Station: 14 + 770.7; offset 5.5 m Rt. of E ORIGINATED BY PD
 DIST 2 HWY 73 BOREHOLE TYPE Cone Penetration Test COMPILED BY PH
 DATUM Geodetic DATE 89 03 30 CHECKED BY ML

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						
266.3	Road Surface						266	Pre-augered			
0.0	Presumed Gravelly Sand										
	(Fill)										
263.3	Presumed Het. Mixture of Clayey Silt Sand and Gravel						264				
3.0	End of Cone Test										

OFFICE REPORT ON SOIL EXPLORATION

UNIFIED SOIL CLASSIFICATION SYSTEM

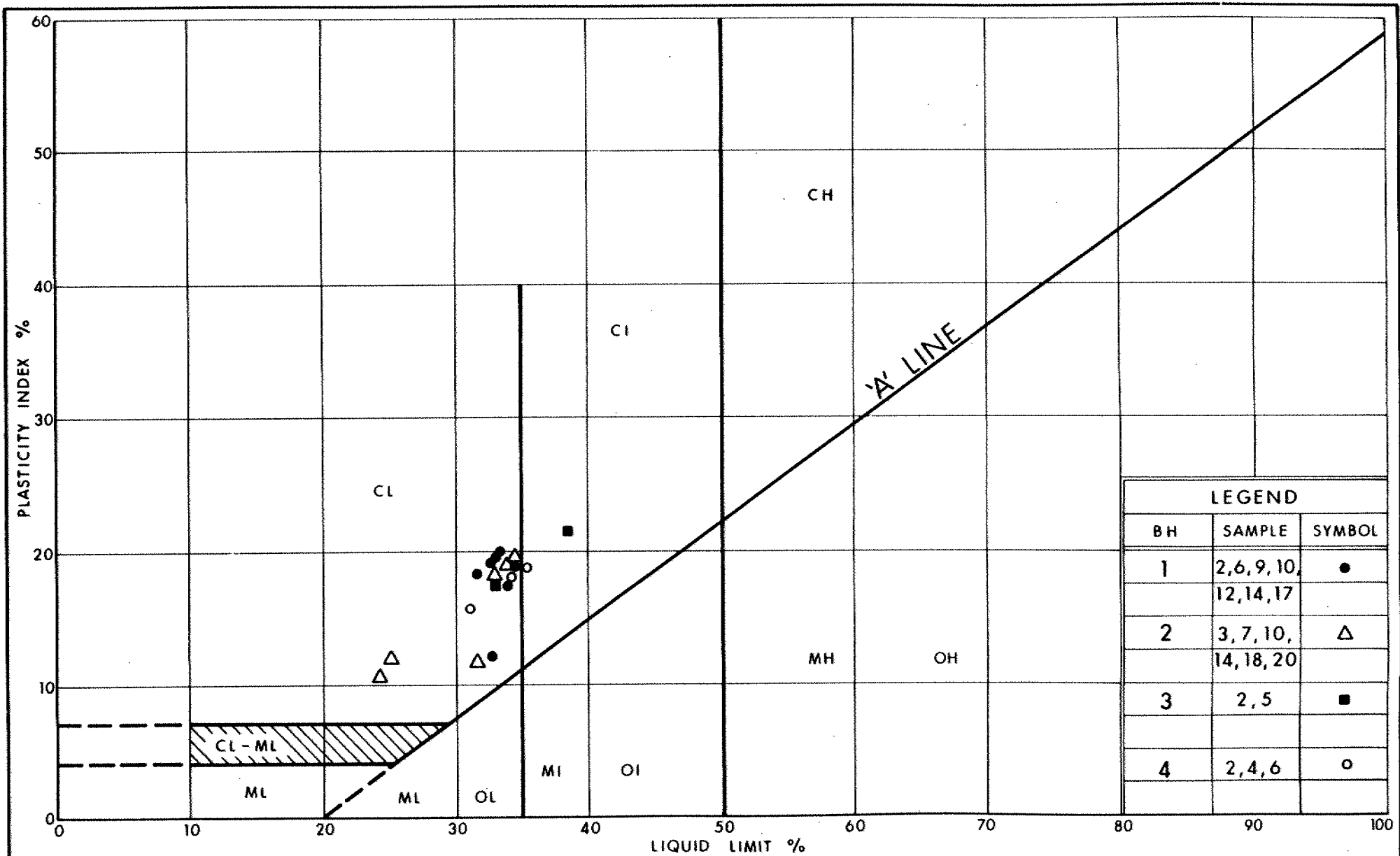


Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
HET MIXTURE OF
CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 1

W P 73-85-02



Ministry of
Transportation
Ontario

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

FIG No 2

W P 73-85-02

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 73-85-01 DIST 2
HWY 73 STR SITE 5-30

Kettle Creek Structure Replacement

CONT 91-07

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FOUNDATION INVESTIGATION REPORT
For
Kettle Creek Structure Replacement
W.P. 73-85-01; Str. Site 5-30
Highway 73, District 2, London

INTRODUCTION

This report contains the results of a Foundation Investigation carried out for the proposed structure replacement and detour at the above location. The fieldwork was carried out from 89-03-20 to 89-03-22. The fieldwork consisted of four sampled boreholes and 6 dynamic cone penetration tests, four of which were adjacent to the boreholes. The borings were advanced by hollow and solid stem augers (57 mm I.D. and 121 mm O.D. respectively), using a machine mounted on a truck.

Sampling was performed to a maximum depth of 12.6 m to elevation 252.9 and the cone tests to a maximum depth of 6.5 m to elevation 258.9.

SITE DESCRIPTION

The site is located approximately 2 km south of Harrietsville on Highway 73 in the Township of South Dorchester. The physiography is undrumlinized Till Plains. At the site Kettle Creek follows a glacial drainage channel to the north of the St. Thomas moraine. This channel is lined with silt and to a less extent with sand and gravel deposits. The land use in the immediate vicinity is agricultural and the terrain is rolling.

SUBSURFACE CONDITIONS

General

The subsoil was found to consist of a heterogeneous mixture of clayey silt, sand and gravel till with occasional zones of sandy silt. This deposit extended from the bottom of the fill along the road to under the 0.6 to 0.9 m of topsoil found off the road to the end of the sampled boreholes. The fill material at the site consisted of (shoulder material) gravelly sand, trace of silt, trace of clay.

The plan and location of boring and the stratigraphical profile are shown on Drawing 738501-A in the attached Appendix. The field and laboratory test results are plotted on the Record of Borehole sheets also in the Appendix of this report. A brief description of the different soil types is given below.

Gravelly Sand (Fill)

This material was found from the road surface (shoulder) to the top of the Heterogeneous mixture of clayey silt, sand and gravel at elevation $263\pm$ to a depth of $2.5\pm$ m. The fill consisted of gravelly sand trace of silt, trace of clay with occasional cobbles.

The natural moisture content (w) of the fill as determined by a laboratory test was 5.5%. The grain size distribution test indicated 42% gravel, 49.5% sand and 8.5% silt and clay. The denseness of the material was compact.

Heterogeneous Mixture of Clayey Silt, Sand and Gravel

The main deposit is a glacial deposit consisting of a heterogeneous mixture of clayey silt, sand and gravel with zones of sandy silt. This deposit was found beneath the surficial material off the road at elevation $263\pm$ and beneath the fill under the shoulders to the end of the borings.

The physical properties of the cohesive material as determined by the field and laboratory tests are as follows:

	<u>Range</u>
Natural Moisture Content (w)	8-23%
Liquid Limit (w_L)	20-43.5%
Plastic Limit (w_p)	10-16.5%

The N-blows from the standard penetration tests averaged at 69, ranging from 17 to 145, tending to become harder with depth. One test indicated a values of 4 at top of layer under the fill. Based on these values the consistency of the material ranged from very stiff to hard. The grain size distribution is shown

on Figure 1 in envelope form. Figure 2 indicates that the majority of the material was a clayey silt (of low plasticity), with some of intermediate plasticity (silty clay).

Within this material, zones of approximately 1 m± thick were found of non-cohesive sandy silt. The natural moisture content of the sandy silt was 19%. The grain size distribution tests indicated 1 to 12% sand and 88 to 99% silt and clay.

GROUNDWATER CONDITIONS

Due to the short duration of the field investigation, no stabilized water levels were obtained with the probable exception of Borehole 4. The water level in Borehole 4 was 2.2 m below the ground surface at approximate elevation 261.5 m. The groundwater level will most likely vary seasonally and with the level in the creek. On 88-10-27 the water level in the creek was at elevation 263.3 m, and on 85-04-04, at elevation 261.7 m.

DISCUSSION AND RECOMMENDATIONS

It is proposed to replace the existing structure along the same alignment and location by a single span concrete Rigid Frame or Concrete Beam Structure, with a grade raise of 0.75 m. A detour is planned for 25 m east of the Highway 73 centreline using corrugated steel pipes and a maximum grade raise of 4.8 m at the creek.

Proposed Structure Replacement

It is recommended that the abutments of the proposed single span structure be founded on spread footings placed below the existing spread footings, (assumed elevation 260.0), at Stations 17+348± and 17+358±. These footings could be placed as follows:

- a) placed below the existing spread footings (assumed elevation 260 m).
- b) mass concrete or well compacted Granular 'A' could be placed from the bottom of the excavation (existing footing elevation) to elevation 261.5 m on to which the footings could be founded.

It is estimated that the footings will achieve a safe bearing capacity of 300 kPa. For the purposes of the O.H.B.D.C., the following design values are recommended:

Factored Capacity at U.L.S. : 450 kPa
Capacity at S.L.S. Type II : 300 kPa

Earth pressure acting on abutments retaining walls and proposed culverts (see below) should be computed as per subsection 6.6.1.2.2. of the O.H.B.D.C. A yielding foundation condition may be assumed. The following properties of granular backfill may be used for computations:

Granular 'A': $\gamma = 22.8 \text{ kN/m}^3$, $\phi = 35^\circ$, $K_a = 0.271$
Granular 'B': $\gamma = 21.2 \text{ kN/m}^3$, $\phi = 30^\circ$, $K_a = 0.333$

For purposes of computing friction resistance to lateral forces the shearing resistance against sliding between the underside of concrete footings and the foundation soil may be assumed to be 0.60. It is further recommended that the surface be roughened before placing of the lean concrete mixture at the base of the footing excavation, so as to increase the bond and resistance to sliding.

For frost protection the base of the footings should have a minimum of 1.2 m of earth cover.

Proposed Detour

The proposed corrugated steel pipes should have a bedding in accordance with M.T.O. OPSD 802.01 and the backfilling in accordance with OPSD 803.03. It is important that the culvert be compacted spontaneously on either side. The invert level should be determined by hydrological requirements with all surficial and any soft to firm material removed.

The existing glacial till has a consistency of very stiff to hard, therefore the underlying deposit is not expected to settle any significant amount with a grade raise of 4.8 m.

Granular material should be used as fill up to 0.5 m above the water table. From 0.5 m below to 0.5 m above the water table Granular 'A' should be used as fill.

Dewatering

Concrete should be placed in the 'dry'. Dewatering is not anticipated to be a major problem although a dewatering scheme will be required for footing excavations below the groundwater level. This could be achieved by sump-pumping. It is also recommended that 15 cm of lean concrete should be poured at the bottom of the footing excavation immediately after completion so as to guard against softening of the foundation material from the effects of weathering, seepage and surface water.

Approach Embankments

Topsoil and surficial material should be removed prior to placing any fill. The fill should consist of well compacted acceptable material.

The side and forward slopes should not be steeper than two horizontal to one vertical designed and constructed in accordance with the appropriate Ministry Standards.

Settlements along the existing alignment with a grade raise of 0.75 m (and along the detour) are likely to be extremely small.

No undue settlements are anticipated during or after construction of the structure foundations since the load required to cause unacceptable settlement would be much greater than the recommended values for factored bearing capacity at U.L.S. (O.H.B.D.C. subsection 6.5.3.2.).

Scour Protection

Scour protection for the footings and abutments should be utilized for this structure. Rip-rap may be used for protection of the river bed and embankments. This rip-rap should be placed so as to be effective from the creek bed to a height of 0.3 m above the high water level and for a span of 5 m up and down stream of the structure.

MISCELLANEOUS

The fieldwork for this investigation was carried out by Mr. P. Dubé, Trainee Engineer. The fieldwork was carried out under the supervision of Mrs. P. Marks, Foundation Engineer, who also prepared this report. The equipment used for the field investigation was owned and operated by London Soil. The entire project was carried out under the general supervision of Mr. P. Payer, Senior Foundation Engineer. The report was reviewed by M. Devata, Chief Foundation Engineer.

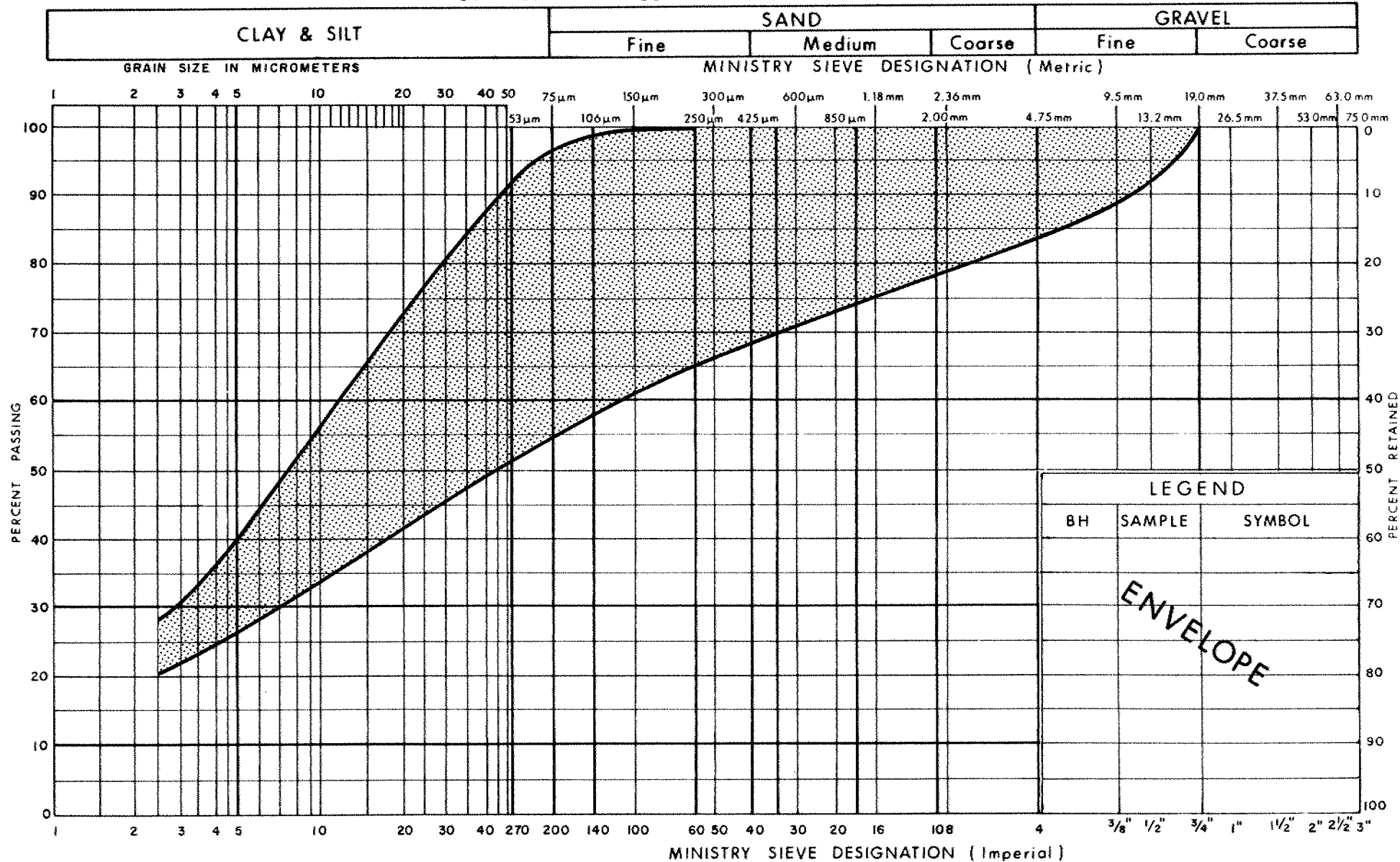


P. Marks
P. Marks, P.Eng.
Foundation Engineer

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

APPENDIX

UNIFIED SOIL CLASSIFICATION SYSTEM



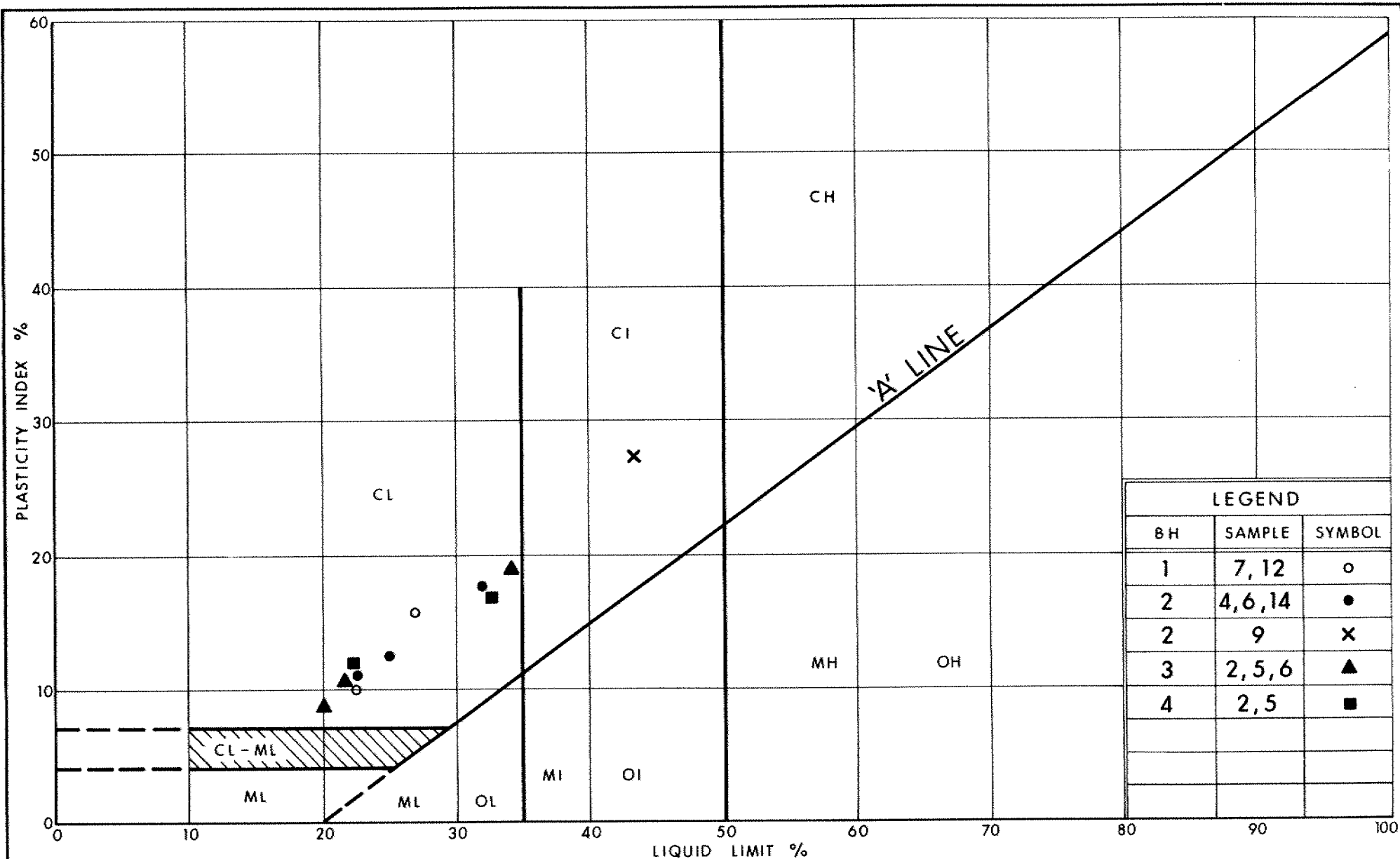
Ministry of
Transportation

Ontario

GRAIN SIZE DISTRIBUTION
HET MIXTURE OF
CLAYEY SILT, SAND & GRAVEL (Glacial Till)

FIG No 1

W P 73-85-01



Ministry of
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Ontario

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

FIG No 2

W P 73-85-01

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 63.5 kg, 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'_{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_r	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 73-85-01 LOCATION Station: 17 + 361.8, offset 5.1 m Lc. of C
DIST 2 HWY 73 BOREHOLE TYPE Continuous Flight Auger (H.S.) & Cone Test
DATUM Geodetic DATE 89 03 20
ORIGINATED BY PD
COMPILED BY PM
CHECKED BY M

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					
265.5	Road Surface													
0.0	Gravelly Sand Trace of Silt Trace of Clay Occ. Cobbles (Fill)		1	SS	10			Pre-augered						
	Compact		2	SS	13		264							42 50 (8)
262.9			3	SS	10									
2.6			4	SS	4	*								
	Heterogeneous Mixture of Clayey Silt Sand and Gravel		5	SS	51		262							
			6	SS	52									
			7	SS	39		260							2 11 (87)
			8	SS	47			120 / 15 cm						
	with Zones of Sandy Silt (Glacial Till)		9	SS	82									
			10	SS	86		258							19 17 (64)
			11	SS	136									
			12	SS	102		256							0 3 71 26
	Hard		13	SS	118									
252.9			14	SS	83		254							0 1 (99)
12.6	End of Borehole													
	* Water level not Established													

RECORD OF BOREHOLE No 2

METRIC

W P 73-85-01 LOCATION Station: 17 + 343.6; offset 5.6 Rt. of E
 DIST 2 HWY 73 BOREHOLE TYPE Continuous Flight Auger (H.S.) & Cone Test ORIGINATED BY PD
 DATUM Geodetic DATE 89 03 20 to 21 COMPILED BY PM
 CHECKED BY *th*

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 kPo					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						GR SA SI CL
265.5	Road Surface								10 20 30					
0.0	Gravelly Sand Trace of Silt Trace of Clay		1	SS	16		264	Pre-augered						
	(Fill)		2	SS	14									26 43 23 8
263.0	Compact		3	SS	11	*	262							2 5 (93)
2.5			4	SS	17		262							60 13 (27)
			5	SS	100/	15 cm		120 / 15 cm						
	Heterogeneous Mixture of Clayey Silt Sand and Gravel		6	SS	120		260							
			7	SS	135									
			8	SS	140		258							0 1 (99)
	with Zones of Sandy Silt		9	SS	39									
	(Glacial Till)		10	SS	105		256							0 12 (88)
			11	SS	220/	25 cm								
	Hard		12	SS	59		254							
			13	SS	145									
252.9			14	SS	136									0 1 (99)
12.6	End of Borehole													
	* Water level not Established													

RECORD OF BOREHOLE No 3

METRIC

W P 73-85-01 LOCATION Station: 17 + 330.7; offset 25.4 m Rt. of E ORIGINATED BY PD
 DIST 2 HWY 73 BOREHOLE TYPE Continuous Flight Auger (S.S.) & Cone Test COMPILED BY PM
 DATUM Geodetic DATE 89 03 21 CHECKED BY fm

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 WATER CONTENT (%) 10 20 30	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
265.1	Ground Surface										
0.0	Topsoil										
264.5											
0.6	Heterogeneous Mixture of Clayey Silt Sand, Gravel (Glacial Till)		1	SS	20		264				5 11 (84)
			2	SS	51						
			3	SS	41						
			4	SS	28		262				15 30 (55)
			5	SS	86						14 17 (69)
260.1	Very Stiff to Hard		6	SS	116						
5.0	End of Borehole										
	*Water level not Established										

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

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0
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10
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50
55
60
65
70
75
80
85
90
95
100
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 4

METRIC

W P 73-85-01 LOCATION Station: 17 + 357.1; offset 24.8 Rt. of E ORIGINATED BY PD
 DIST 2 HWY 73 BOREHOLE TYPE Continuous Flight Auger (S.S.) & Cone Test COMPILED BY PM
 DATUM Geodetic DATE 89 03 22 CHECKED BY M

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						
263.7	Ground Surface										
0.0	Topsoil										
262.8			1	SS	8						
0.9	Heterogeneous Mixture of Clayey Silt, Sand and Gravel		2	SS	34						2 7 (91)
			3	SS	24						43 49 7 1
	(Glacial Till)		4	SS	41						
	Hard		5	SS	38						9 17 (74)
258.7			6	SS	79						
5.0	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 5

METRIC

W P 73-85-01 LOCATION Station: 17 + 358.9; offset 5.2 m R. of E ORIGINATED BY PD
DIST 2 HWY 73 BOREHOLE TYPE Cone Penetration Test COMPILED BY PM
DATUM Geodetic DATE 89 03 21 CHECKED BY 11

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						
265.5	Road Surface										
0.0	Presumed Gravelly Sand										
	(Fill)										
261.5	Presumed Het. Mixture of Clayey Silt Sand and Gravel										
4.0	End of Cone Test										

OFFICE REPORT ON SOIL EXPLORATION

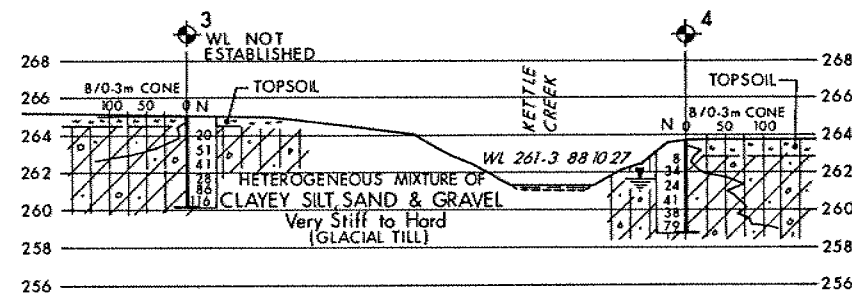
RECORD OF BOREHOLE No 6

METRIC

W P 73-85-01 LOCATION Station: 17 + 344.8; offset 4.9 m Lt. of E
 DIST 2 HWY 73 BOREHOLE TYPE Cone Penetration Test
 DATUM Geodetic DATE 89 03 21
 ORIGINATED BY PD
 COMPILED BY PM
 CHECKED BY

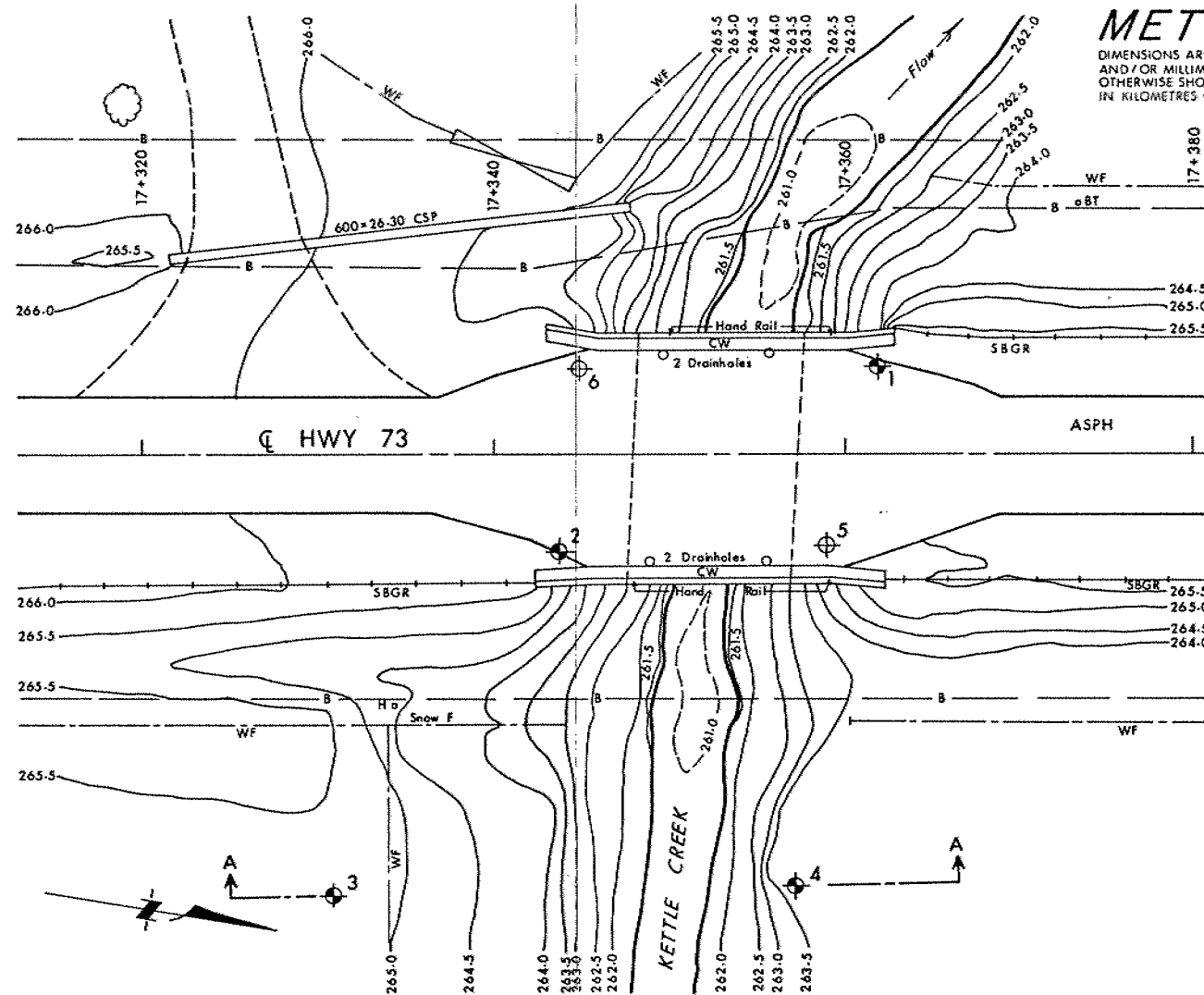
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
265.5	Road Surface										
0.0	Presumed Gravelly Sand										
	(Fill)										
261.0	Presumed Het. Mixture of Clayey Silt Sand and Gravel										
4.5	End of Cone Test										

OFFICE REPORT ON SOIL EXPLORATION



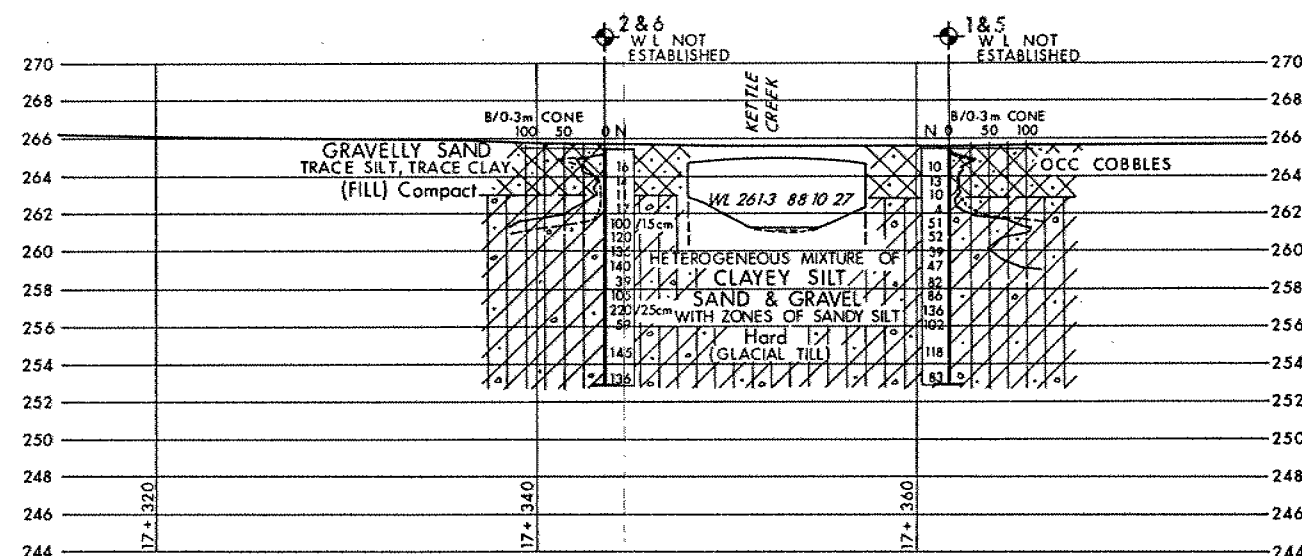
SECTION A-A

SCALE
4m 2 0 4m



PLAN

SCALE
4m 2 0 4m



PROFILE HWY 73

SCALE
4m 2 0 4m

METRIC

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

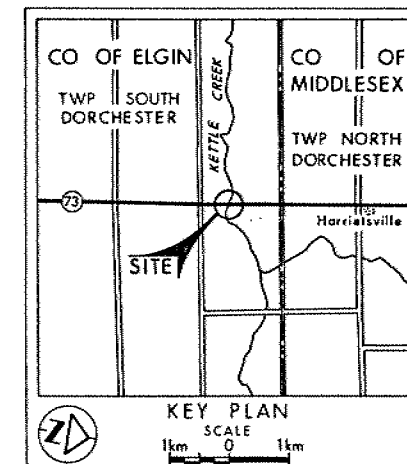
CONT No
WP No 73-85-01

KETTLE CREEK

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)
- WL at time of investigation 89 03

No	ELEVATION	STATION	OFFSET
1	265.5	17+361.8	5.1 m LT
2	265.5	17+343.6	5.6 m RT
3	265.1	17+330.7	25.4 m RT
4	263.7	17+357.1	24.8 m RT
5	265.5	17+358.9	5.2 m RT
6	265.5	17+344.8	4.9 m LT

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.

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