

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 3015-123

DIST. 4 REGION

W.P. No. 83-74-28

CONT. No. 91-22

W. O. No.

STR. SITE No. 10-320

HWY. No. QEW/403

LOCATION Proposed Bridge, Interchange

No of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

FOUNDATION INVESTIGATION REPORT

CONTRACT NO 91-22



Ministry of
Transportation

CONT 91-22

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	Q.E.W. N.B.L. - Ramp S.to Hwy. 403 Underpass and
	Q.E.W. S.B.L. - Ramp S.to Hwy. 403 Underpass W.P. 83-74-28/29, Site 10-320 and 10-321 Hwy. 403/Q.E.W., District 4 (Burlington)
	Q.E.W. S - Hwy. 403 Ramp Over N. Service Rd. W.P. 199-77-12, Site 10-1337-339 Hwy. 403/Q.E.W., District 4 (Burlington)
	Brant St. Underpass W.P. 199-77-13, Site 10-1337-340 Hwy. 403, District 4 (Burlington)

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

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/0.3 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

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

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 = $\frac{c_u}{\tau_r}$

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						



Golder Associates

CONSULTING GEOTECHNICAL AND MINING ENGINEERS

REPORT
TO

MINISTRY OF TRANSPORTATION
AND COMMUNICATIONS

FOUNDATION INVESTIGATION
PROPOSED OVERPASS BRIDGES AT Q.E.W./
HWY. 403

WP 83-74-28/29

DISTRICT 4

1.0 INTRODUCTION

Golder Associates have been retained by the Ministry of Transportation and Communications (letter dated December 5, 1980) to carry out a foundation investigation for two proposed overpass bridges on the QEW/403 Interchange in Burlington, Ontario (overall W.P. 837407).

The purpose of the investigation was to determine the subsurface conditions at the site and based on these data, to provide engineering recommendations for the geotechnical design of the foundations for the proposed structures.

The investigation was carried out, and this report was prepared, in accordance with Golder Associates' letter, dated December 23, 1980.

2.0 DESCRIPTION OF PROJECT

Details of the project were provided during a meeting between Mr. Selby of the Ministry of Transportation and Communications, and Messrs. Davis and Busbridge of Golder Associates on December 15, 1980. Additional details were provided on two plans titled "Bridge Site, Proposed Northbound QEW Underpass at Ramp QEW-S to Hwy. 403" designated Site 10-320, W.P. 837428 dated September 30, 1980, and "Bridge Site, Proposed Southbound QEW Underpass at Ramp QEW-S to Hwy. 403" designated Site 10-321, W.P. 837429 dated October 1, 1980, and in an M.T.C. memorandum dated October 27, 1980. It is understood that the above mentioned projects form part of overall W.P. 837407.

It is understood that at Site 10-320, the proposed bridge will be a four span post-tensioned type with spans of approximately 22 m, 45 m, 39 m and 22 m. It will allow for QEW northbound traffic to proceed westerly along Hwy. 403. The centre column is to be located at the median of the future QEW.

At Site 10-321 it is understood that the proposed bridge will be a three span post-tensioned type with spans of approximately 20 m, 40 m and 20 m. It will allow for traffic carried by the previous bridge deck to overpass the future QEW southbound lanes and proceed westerly along Hwy. 403.

The approximate locations of the footings were shown in red on the two plans provided, along with profiles of both QEW and the ramps under consideration in this area.

3.0 SITE AND GEOLOGY

The proposed bridges are to be located along the QEW, south of the North Service Road and west of Brant Street in the City of Burlington, Ontario. The topography at the site is generally flat lying having an elevation about 106 m (Geodetic). Immediately to the north of the site the land rises towards the Niagara Escarpment.

The site is located in the physiographic region known as the Iroquois Plain, consisting of a narrow strip of land along the shores of the present Lake Ontario. This level plain was formed by post-glacial Lake Iroquois which then occupied the Lake Ontario basin. In the Burlington area the surficial soils in this plain consist of beach sands, clayey silt till and/or residual red clayey silt derived from weathering of the underlying Queenston shale bedrock. The Queenston shale formation consists of thinly bedded red clay shale with occasional bands of grey limestone.

4.0 INVESTIGATION PROCEDURE

The field work for this investigation was carried out between December 22 and 31, 1980. The elevations of the boreholes were determined on January 5, 1981. During this time nine boreholes were put down at the two sites (Drawings 837428-A* and 837429-A)** using a Type 5.3.i drillrig supplied and operated by Master Soil Investigations Ltd., of Toronto, a specialist drilling contractor. Within the overburden soils the boreholes were advanced with solid stem augers. In each

* DWG NO 3 OF THE CONTRACT DWG'S

** " " 2 " " " "

boring, standard penetration tests were carried out at 0.76 m intervals of depth, and samples were obtained using a standard 50 mm O.D. split spoon sampler, which was advanced by a 63.5 kg mass falling freely for 0.76 m. In each boring, bedrock was cored for depths of between 2.8 m to 3.8 m in BXL size. Details of the drilling and sampling operations are summarized on the Record of Borehole sheets. A filtered standpipe was sealed into each boring to allow monitoring of the groundwater level.

The field work was supervised throughout by a member of Golder Associates' engineering staff, who located the borings in the field, cleared underground services, directed the drilling and sampling operations, logged the borings and cared for the samples. The borehole locations were established by tape measurement. The ground surface elevations at each boring was determined relative to an M.T.C. survey monument (Drawing 837428-A)*. The elevation of this control point was provided by a member from the M.T.C. staff on January 8, 1981. It is understood that all ground surface elevations are referred to Geodetic datum.

Following field identification and logging, all the samples obtained during the investigation were placed in air-tight containers and brought to our laboratory where they were examined in detail. Representative samples of the soil were tested to determine their index properties.

5.0 SUBSURFACE CONDITIONS

The detailed stratigraphy encountered in each of the boreholes together with the results of laboratory tests carried out on representative samples of the soil strata are given on the attached Record of Borehole sheets and on Figures 1 to 3. The locations of the boreholes and the simplified stratigraphy at the boreholes are shown on Drawings 837428-A* and 837429-A.** It should be noted that the stratigraphic boundaries indicated on the borehole logs and longitudinal sections are inferred from a transition from one soil type

* DWG NO 3 OF THE CONTRACT DWG'S

** " " 2 " " " "

to another and do not necessarily indicate an exact plane of geologic change. Further, the subsurface conditions may vary between boreholes.

5.1 Site 10-320

At the locations of Boreholes 5, 6 and 8, up to 0.3 m of topsoil was encountered at ground surface. A layer of granular material comprising crushed stone (sand and gravel sizes) was encountered at Borehole 7 and extends to a depth of 1.4 m (Elev. 104.8 m). This material forms part of the shoulder of the existing Highway 403 exit ramp to the QEW. The topsoil at Boreholes 5, 6 and 8, the granular fill at Borehole 7 as well as ground surface at Borehole 9 are underlain by a layer of clayey silt containing some sand and gravel, pieces of red brick and occasional thin lenses of black organic matter. This fill varies in thickness from 0.6 m at Boreholes 5 to 2.0 m at Borehole 7. The fill is underlain by hard (N values greater than 30) clayey silt containing a trace of sand and gravel to sandy silt containing some gravel, with red shale fragments throughout.

The clayey silt material has a grain size distribution (Figures 1 and 2) similar to that of a glacial till. However, the coarser fraction of the soil is angular and easily friable. This material has the characteristics of a residual soil (soil material with the original texture, structure and mineralogy of the rock completely destroyed) rather than the matrix of a glacial till. It extends to a depth of about 2.3 m (between Elev. 100.1 m to 103.2 m) below ground surface except at Borehole 7 where it extends to 4.4 m (Elev. 101.8 m) below ground surface. The fill has a grain size distribution similar to that of the residual soil (Figure 1 - BH7, SA 3) and is probably local material placed during previous construction activities.

The water content of the sandy silt is about 10 per cent and that of the clayey silt is about 17 per cent. Both

materials (forming the residual soil) exhibit low plasticities with liquid limits between 16 to 22 per cent and a plasticity index of about 2 (Figure 3). The residual soil encountered at Boreholes 5 and 9 is more granular (Figure 2) than that of Boreholes 6, 7 and 8, possibly due to it containing more weathered shale fragments. This material is underlain by highly weathered to faintly weathered, reddish brown, weak to strong Queenston shale. The shale is irregularly banded with grey limestone layers about 80 mm in thickness and an occasional thin seam of red clay. The core recovery was generally in excess of 70 per cent and the Rock Quality Designations (RQD) lies between zero and 80 per cent, the higher quality being recorded for core recovered about 2 m below the overburden/bedrock interface.

As is evidenced from the profile shown on Drawing 837428-A* ground surface and the various stratigraphic units slope gently from north (BH 5) to south (BH 9). The top surface of the residual soil also slopes towards the south but is more erratic due to the surface having been changed by previous construction activities and fill placement. The elevation of Borehole 7 is higher than the other boreholes in the same general area due to it being located near the southern shoulder of the exit ramp from Hwy. 403.

The groundwater surface measured in the standpipes also slopes towards the south generally following the ground surface topography.

5.2 Site 10-321

At the location of Boreholes 1 to 4 the ground surface is underlain by between 0.12 and 0.36 m of topsoil. At Boreholes 3 and 4, the topsoil overlies a layer of fill composed of clayey silt containing some sand and gravel, pieces of red brick and occasional thin lenses of black organic matter. The fill extends to a depth of 1.1 and 0.5 m (Elev. 104.9 and 105.1 m) below ground surface at the location of these two boreholes. The topsoil at Boreholes 1 and 2 and the fill at

* DWG NO 3 OF THE CONTRACT DWG'S

Boreholes 3 and 4 is underlain by between 0.7 and 1.6 m of stiff to hard (N values 17 to 39) reddish brown clayey silt containing a trace of sand and gravel and numerous red shale fragments, and is considered to be residual soil. The residual soil was penetrated to about 1.5 to 1.8 m (Elev. 103.8 to 104.7 m) below ground surface at which depths refusal to augering was encountered. The higher 'N' values given on the Record of Borehole sheets and on the profile shown on Drawing 837429-A* were obtained at the overburden/bedrock contact.

The water content of the residual soil lies between 11 and 16 per cent which is below the plastic limit of the material and indicative of a heavily overconsolidated soil. The material exhibits low plasticity with a plasticity index of about 10 (Figure 3).

Bedrock was extracted by BXL rock coring techniques. The bedrock was found to be a highly weathered to faintly weathered at depth, reddish brown, weak to strong at depth, Queenston shale. The shale is irregularly banded with grey limestone layers about 80 mm in thickness, and is occasionally intercepted by thin seams of red clay. The core recovery was about 73 per cent and the RQD was between zero and 60 per cent and generally below 50 per cent. This indicates that the shale bedrock is of generally poor to fair quality.

The groundwater level measured within the standpipes slopes towards the south, generally following the surface topography. Although the water level is indicated as being higher at Borehole 3 than at Borehole 2 this may be due to an interceptor ditch located near Borehole 2 thereby depressing the water level in this area.

* DWG NO 2 OF THE CONTRACT DWG'S

NOTE: The preceding report is a copy of the factual information from the Foundation Investigation Report prepared by Golder Associates Ltd. (consulting geotechnical engineers for this project), under the technical supervision of the MTO Foundation Design Section.

RECORD OF BOREHOLE No.1

METRIC

W P 83-74-29 LOCATION Co-ords 4,799,746N: 278,076 E (STA 8+ 921) ORIGINATED BY A.H.T.
 DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
 DATUM Geodetic DATE December 22, 1980 CHECKED BY J.S.K.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
106.24	Ground Level																
0.00	Topsoil																
105.88	Clayey Silt with shale fragments (Residual soil). Hard.		1	SS	39												
0.36	Red and Greenish Grey.		2	SS	50/107												
104.72	Shale Bedrock.																
1.52	Highly weathered reddish brown, fine grained, weak, irregularly banded with grey lime- stone layers about 80mm thick. 76mm clay seam at Elev. 103.3 m.		3	R.C.													
			4	BXL	89%												
101.70																	
4.54	End of Borehole.																

RECORD OF BOREHOLE No. 2

METRIC

W P 83-74-29 LOCATION Co-ords 4,799,727 N; 278,084 E (STA 8+942.5) ORIGINATED BY A.H.T.
 DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
 DATUM Geodetic DATE December 23, 1980 CHECKED BY J. Smith

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100						SHEAR STRENGTH			WATER CONTENT (%)
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE															
106.33	Ground Level																				
106.08	Topsoil																				
0.24	Clayey Silt, some shale fragments (residual soil).																				
	Very Stiff.																				
104.50	Reddish Brown.																				
1.83	Shale Bedrock, highly weathered, reddish brown, fine grained, weak.		2	SS	17																
	32mm clay seam at Elev. 103.7 m.		3	RC BXL	91%																
103.28	Shale Bedrock.																				
3.05	Faintly weathered reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		4	RC BXL	100%																
101.21			5	RC BXL	100%																
5.12	End of Borehole.																				

RECORD OF BOREHOLE No. 3

METRIC

W P 83-74-29 LOCATION Co-ords 4,799,692 N; 278,102 E (STA 8+982.5) ORIGINATED BY A.H.T.
DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
DATUM Gaudetie DATE December 23, 1980 CHECKED BY J. M. C.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100				
105.96	Ground Level															
0.00	Topsoil															
0.12	Clayey Silt (Fill).															
104.89	Hard. Brown to Black.		1	SS	17											
1.07	Clayey Silt, with shale fragments (Residual Soil)															
104.19	Hard, Reddish brown.		2	SS	115											
1.77	Shale Bedrock. Highly weathered. Reddish brown, fine grained, weak.		3	RC BXL	73%											
103.16	Shale Bedrock. Faintly weathered, reddish brown, fine grained, strong. Irregularly banded with gray limestone layers about 80 mm thick.		4	RC BXL	92%											
2.80			5	RC BXL	100%											
101.33	End of Borehole.															
4.63																

RECORD OF BOREHOLE No.4

METRIC

W P 83-74-29 LOCATION Co-ords 4,799,673 N; 278,111 E (STA 9+002.5) ORIGINATED BY A.H.T.
DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
DATUM Geodetic DATE December 23 & 24, 1980 CHECKED BY J.C.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE										10 20 30		
105.56	Ground Level																			
0.00	Topsoil						Seal													
0.12	Clayey Silt (Fill).						105													
105.10	Stiff, Brown.																			
0.46	Clayey Silt, some gravel and shale fragments (Residual Soil).		1	SS	23		Backfill						O			3 13 73 11				
103.79	Hard, Reddish Brown.		2	SS	84		104													
1.77	Shale Bedrock.			Rc												RQD 53%				
103.33	Moderately Weathered.		3	BXL	98%		103													
2.23	Shale Bedrock. Faintly weathered, reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		4	BXL	97%		Pen Gravel 102									RQD 33%				
100.96							101									Standpipe frozen at ground level on Jan. 5/81				
4.60	End of Borehole.						100													

RECORD OF BOREHOLE No. 5

METRIC

W P 83-74-28 LOCATION Co-ords, 4,799,633 N; 278,130 E (STA 9+047) ORIGINATED BY A.H.T.
DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
DATUM Geodetic DATE December 29, 1980 CHECKED BY J.W.C.

[illegible]

RECORD OF BOREHOLE No.6

METRIC

W P 83-74-28 LOCATION Co-ords, 4,799,610N; 278,139E (STA. 9+071) ORIGINATED BY A.H.T.
DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
DATUM Geodetic DATE December 29, 1980 CHECKED BY J.C.C.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100		
105.47	Ground Level													
0.0	Topsoil													
0.15	Clayey to Sandy Silt, some gravel (Fill).		1	SS	17	Seal	105							
			2	SS	18	Backfill	104							
103.67	Compact, Brown.		3	SS	38									
1.80	Clayey Silt, some gravel (Residual Soil).													
103.13	Hard. Reddish Brown.		4	SS	70/152	Seal	103							
2.34	Shale Bedrock. Moderately weathered reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		5	RC	98%		102							RQD 23%
101.63				BXL										
3.84	Shale Bedrock. Faintly weathered reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		6	RC	100%	Pea Gravel	101							RQD 57%
				BXL			100							
99.80	End of Borehole.						99							W.L. elev. 103.85 on Jan. 5/81

RECORD OF BOREHOLE No. 7

METRIC

W P 83-74-28 LOCATION Co-ords. 4,799,575N; 278,151E (STA. 9+108) ORIGINATED BY A.H.T.
DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
DATUM Geodetic DATE December 30, 1980 CHECKED BY J.H.C.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
106.22	Ground Level																
0.0	Crushed Stone (Sand and Gravel sizes) (Fill).						Seal										
104.85	Very Dense, Brown.		1	SS	59												
1.37	Clayey Silt, some sand, trace gravel (Fill).		2	SS	44												
	Stiff to Hard.		3	SS	13												
102.84	Brown.		4	SS	40												
3.38	Clayey Silt, some sand, trace gravel and shale fragments (Residual Soil).		5	SS	60/152												
101.80	Hard. Reddish Brown.		6	SS	60/152												
4.42	Shale Bedrock. Highly weathered. Reddish brown. Fine grained. Weak.		7	RC	39%												
100.73			8	RC	120%												
5.49	Shale Bedrock. Moderately weathered reddish brown, fine grained, strong. Irregular banded with grey limestone layers about 80 mm thick.		9	RC	78%												
99.15			10	BXL	86%												
7.07	Shale Bedrock. Faintly weathered. Reddish brown with irregular grey limestone bands.																
98.08	Fine grained. Strong.																
8.14	End of Borehole.																

RECORD OF BOREHOLE No.8

METRIC

W P 83-74-28 LOCATION Co-ords. 4,799,531N; 278,161E (STA. 9+152) ORIGINATED BY A.H.T.
 DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
 DATUM Geodetic DATE December 29 & 30, 1980 CHECKED BY J.W.C.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
103.01	Ground Level																GR SA SI CL
0.00																	
102.70	Topsoil																
0.31	Sandy Silt to Clayey Silt (Fill). Very Stiff. Brown.																
102.06																	
0.95	Sandy Silt to Clayey Silt with gravel (Residual Soil).		1	SS	35		102										
101.18	Hard. Reddish Brown.		2	SS	65/152	mm											
1.83	Shale Bedrock. Highly weathered. Reddish brown with irregular grey limestone bands about 80 mm thick. Fine grained. Weak.		3	RC	44%		101										RQD 0%
			4	BXL	100%		100										RQD 34%
99.11																	
3.90	Shale Bedrock. Slightly weathered. Reddish brown with irregular grey lime- stone bands about 80 mm thick. 75 mm clay seam at Elev. 99.1 m. Fine grained. Strong.		5	RC	99%		99										RQD 45%
			6	BXL	100%												RQD 100%
97.68			7	RC	100%		98										RQD 100%
				BXL													
5.33	End of Borehole.						97										W.L. elev. 102.13 on Jan. 5/81

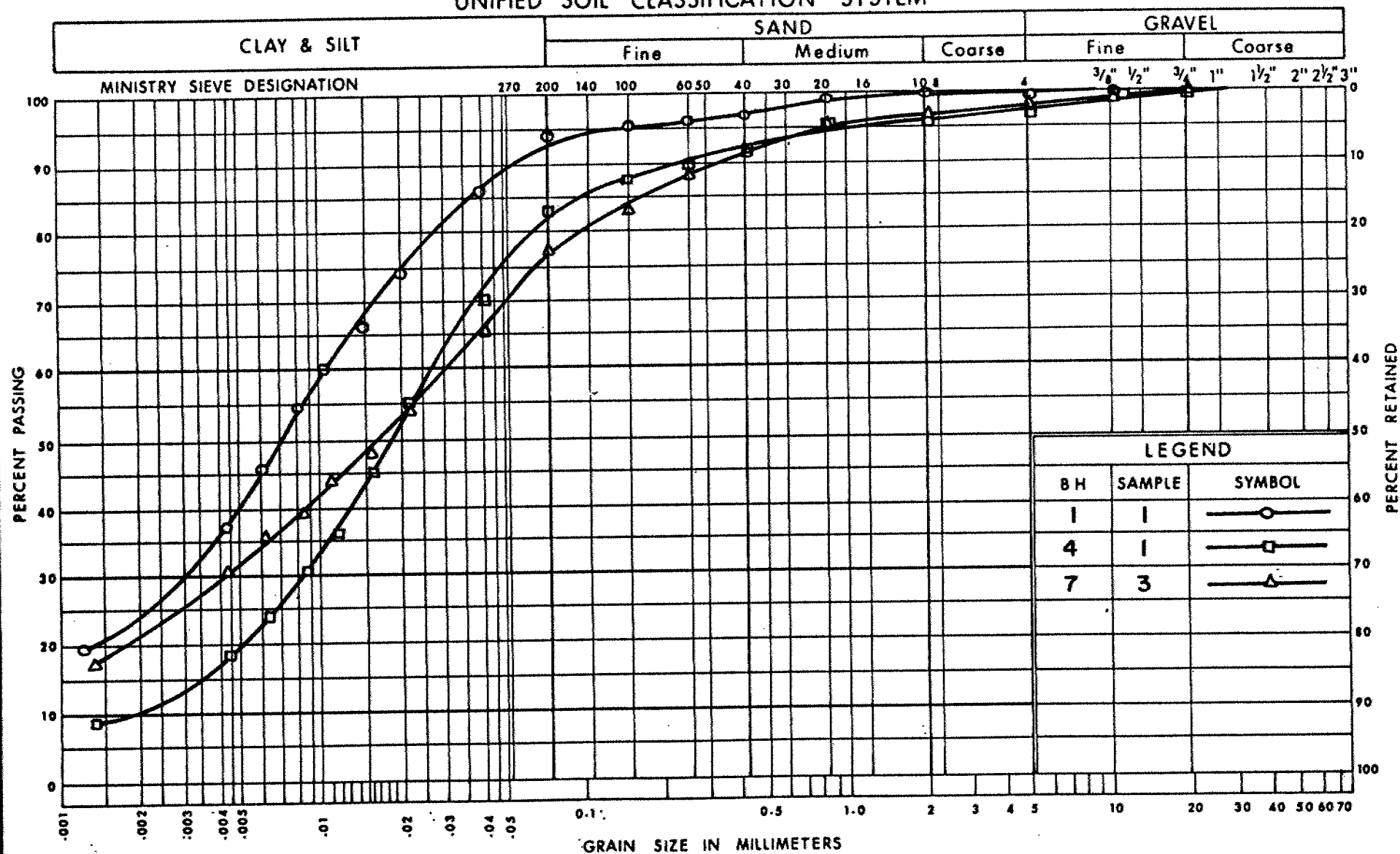
RECORD OF BOREHOLE No 9

METRIC

W P 83-74-28 LOCATION Co-ords. 4,799,508N; 278,165E (STA. 9+175) ORIGINATED BY A.H.T.
 DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
 DATUM Geodetic DATE December 30 & 31, 1980 CHECKED BY J.M.C.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
102.44	Ground Level																GR SA SI CL
0.00	Clayey Silt to Sandy Silt, some gravel (Fill). Stiff.						Seal										
101.37	Dark brown to black.		1	SS	19		Backfill										
1.07	Sandy Silt, some gravel, trace clay (Residual Soil).		2	SS	86		101										12 31 53 4
100.15	v. dense. Reddish Brown.						Seal										
2.29	Shale bedrock, slightly weathered reddish brown with grey limestone bands. Short vertical fracture at elev. 99.3 m.		3	SS	60/76		100										RQD 35%
99.09	Fine grained. Strong.		4	RC	88%												RQD 50%
3.35	Shale bedrock, faintly weathered. Reddish brown with grey limestone bands about 80 mm thick. Clay seam at elev. 98.4 m.		5	RC	98%		99										
	Fine grained. Strong.		6	BXL	98%		Pea Gravel										RQD 70%
96.95							98										
5.49	End of Borehole.						97										W.L. elev. 101.74 on Jan. 5/81
							96										

UNIFIED SOIL CLASSIFICATION SYSTEM



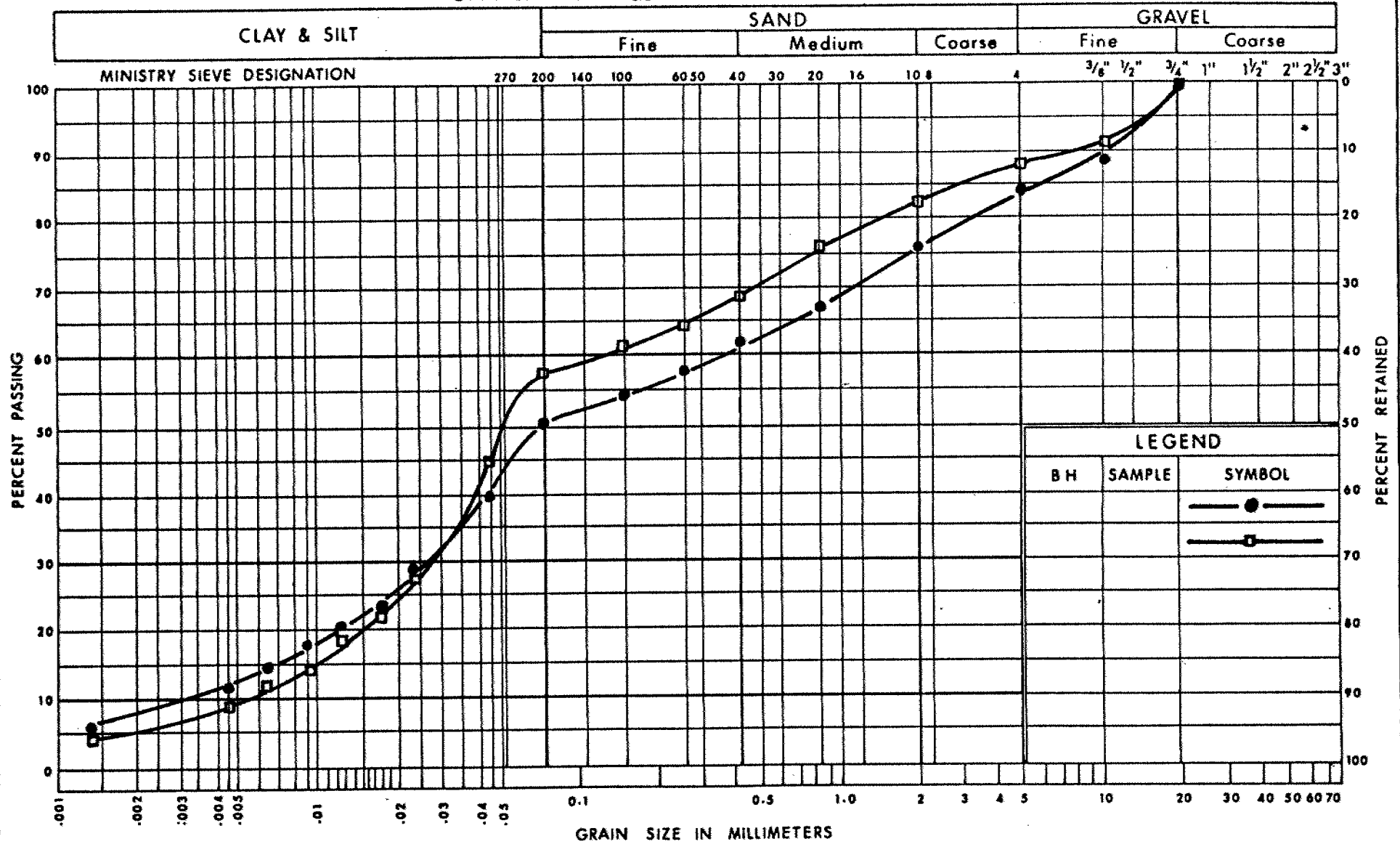
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Communications

GRAIN SIZE DISTRIBUTION
CLAYEY SILT, TRACE SAND (RESIDUAL SOIL)

FIG No 1

W P 83-74-28/29

UNIFIED SOIL CLASSIFICATION SYSTEM

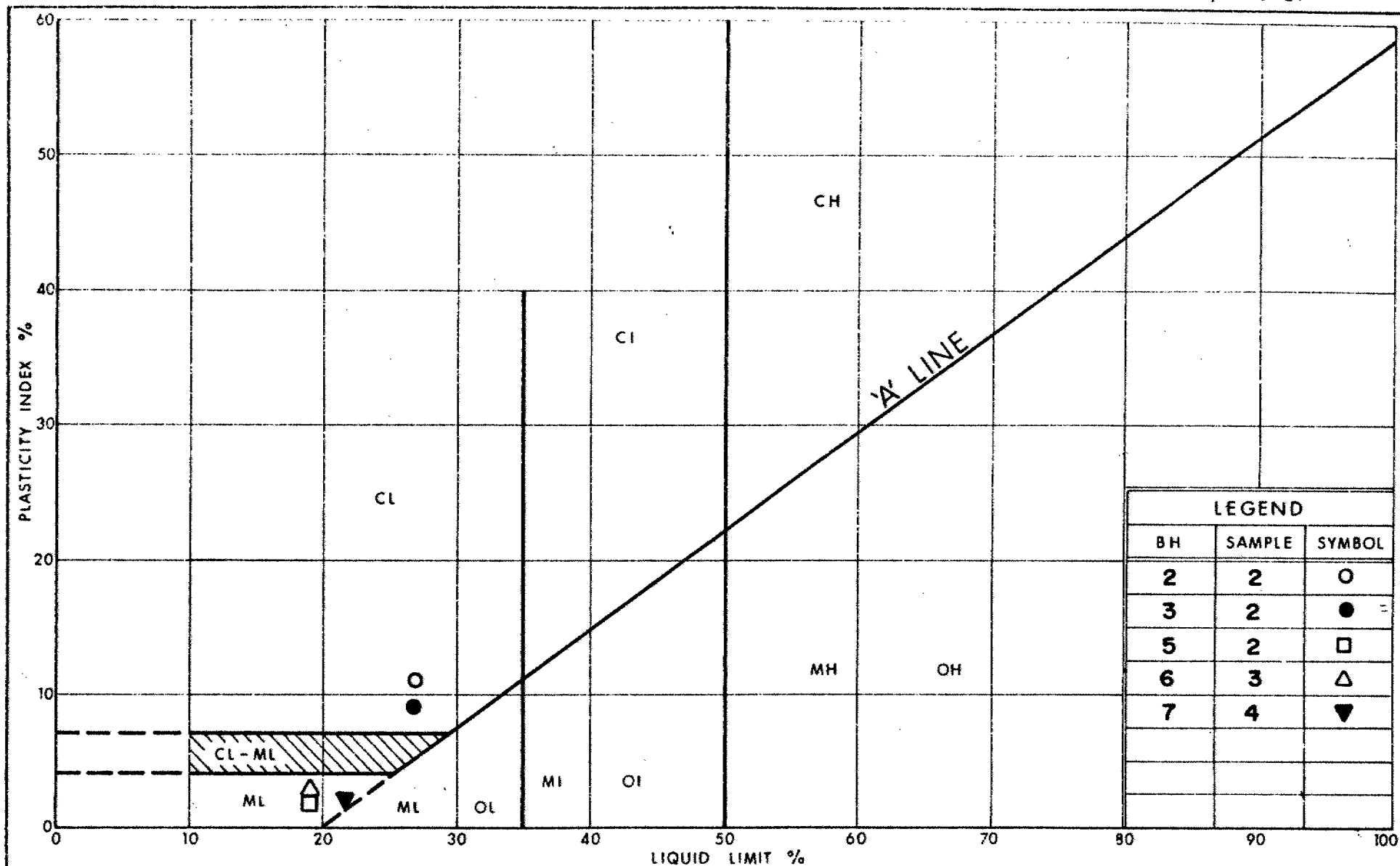


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Communications

GRAIN SIZE DISTRIBUTION
SANDY SILT (RESIDUAL SOIL)

FIG No 2

W P 83-74-28/29



LEGEND		
BH	SAMPLE	SYMBOL
2	2	○
3	2	●
5	2	□
6	3	△
7	4	▼



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Communications

PLASTICITY CHART

FIG No **3**

W P 83-74-28/29

For

Q.E.W. S - 403 E Ramp over North Service Road

W.P. 199-77-12, Site 10-1337-339

District 4, BurlingtonINTRODUCTION

This report summarizes the factual information obtained from a foundation investigation performed at the above-mentioned site. Fieldwork consisted of four sampled boreholes and eight dynamic cone penetration tests advanced between 85 02 14 and 85 02 19. A track mounted auger machine was employed for the investigation. Borings were advanced for depths ranging from 2.9 m to 12.1 m. Bedrock was cored utilizing BXL size in all four boreholes.

SITE DESCRIPTION

The site is located approximately 550 m west of existing Brant St. and about 130 m north of the existing North Service Road in the City of Burlington, Regional Municipality of Halton.

It is proposed to construct a three span precast concrete structure to accommodate traffic movements from the Q.E.W. south to the future 403 eastbound over the relocated North Service Road. This site has been used as a borrow area for existing contracts and therefore the proposed relocated North Service Road, which is located in a cut in this vicinity, has been excavated approximately to subgrade.

The site is located in the physiographic region known as the South Slope. The area is characterized by a ground moraine of limited relief. The underlying bedrock is a red shale with siltstone, of the Queenston Formation.

SUBSURFACE CONDITIONSGeneral

This report must be read in conjunction with the Record of Borehole Sheets located in the Appendix as well as Dwg. #1997712-A* which shows the locations and elevations of the borings along with an estimated stratigraphical profile based on the borehole data.

The subsoil conditions are fairly uniform across the site. Exposed at ground surface at boreholes 1, 3 and 7, and underlying approximately 1.0 m of silty clay fill at borehole 5, is a heterogeneous mixture of silty clay containing varying proportions of sand and gravel and occasional cobbles and boulders. This deposit overlies bedrock.

* DWG NO 2 OF THE CONTRACT DWG'S

The various soil types encountered are described in the following paragraphs.

Fill

An approximately 1.0 m thick layer of silty clay, trace organics and gravel was encountered at borehole 5. Based on one Standard Penetration Test 'N' value, the consistency of this deposit is considered to be stiff.

Heterogeneous Mixture of Silty Clay, Sand and Gravel (Glacial Till)

This deposit is the predominant soil type across the site. It was encountered in all boreholes and ranged in thickness from 6.2 m at borehole 7 to 9.4 m at borehole 1. It consists of a heterogeneous mixture of silty clay with varying proportions of sand and gravel. Occasional cobbles and boulders were encountered during the investigation.

The results of water content and Atterberg Limit testing are plotted on the Plasticity Chart, Figure #1 and are summarized as follows:

		Range	Average
Water Content	(W)%	8-18	13
Liquid Limit	(W _L)%	25-28	26
Plastic Limit	(W _p)%	15-17	16
Plasticity Index	(I _p)%	9-12	10

Grain size distribution tests were carried out on representative samples and the results of these tests are shown in envelope form on Figure #2 in the Appendix.

Standard Penetration Test 'N' values ranged from 13 to over 100 blows per 0.3 m penetration. Based on these results, the consistency of this deposit varies from stiff to hard.

Bedrock

Bedrock was proven by obtaining up to 3.0 m of BXL rock core.

Generally, the bedrock is a red shale with green unweathered siltstone (approx. 10%) of the Queenston Formation. The upper portion of the bedrock is highly weathered. A detailed description of the rock core was prepared by Mr. E. Magni, M.T.C. Geologist and his report is located in the Appendix.

Groundwater

The groundwater level was not encountered during the drilling operations.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of Mr. R. Thomas, Student Specialist Engineer, utilizing equipment owned and operated by Atcost Soil Drilling Inc., Concord. This report was written by Mr. B. Ruck, Project Foundations Engineer and reviewed by Mr. K. Selby, Chief Foundations Engineer (West).



A handwritten signature in cursive script, appearing to read "P. Payer".

P. Payer, P. Eng.
Sr. Foundation Engineer

A handwritten signature in cursive script, appearing to read "M. Devata".

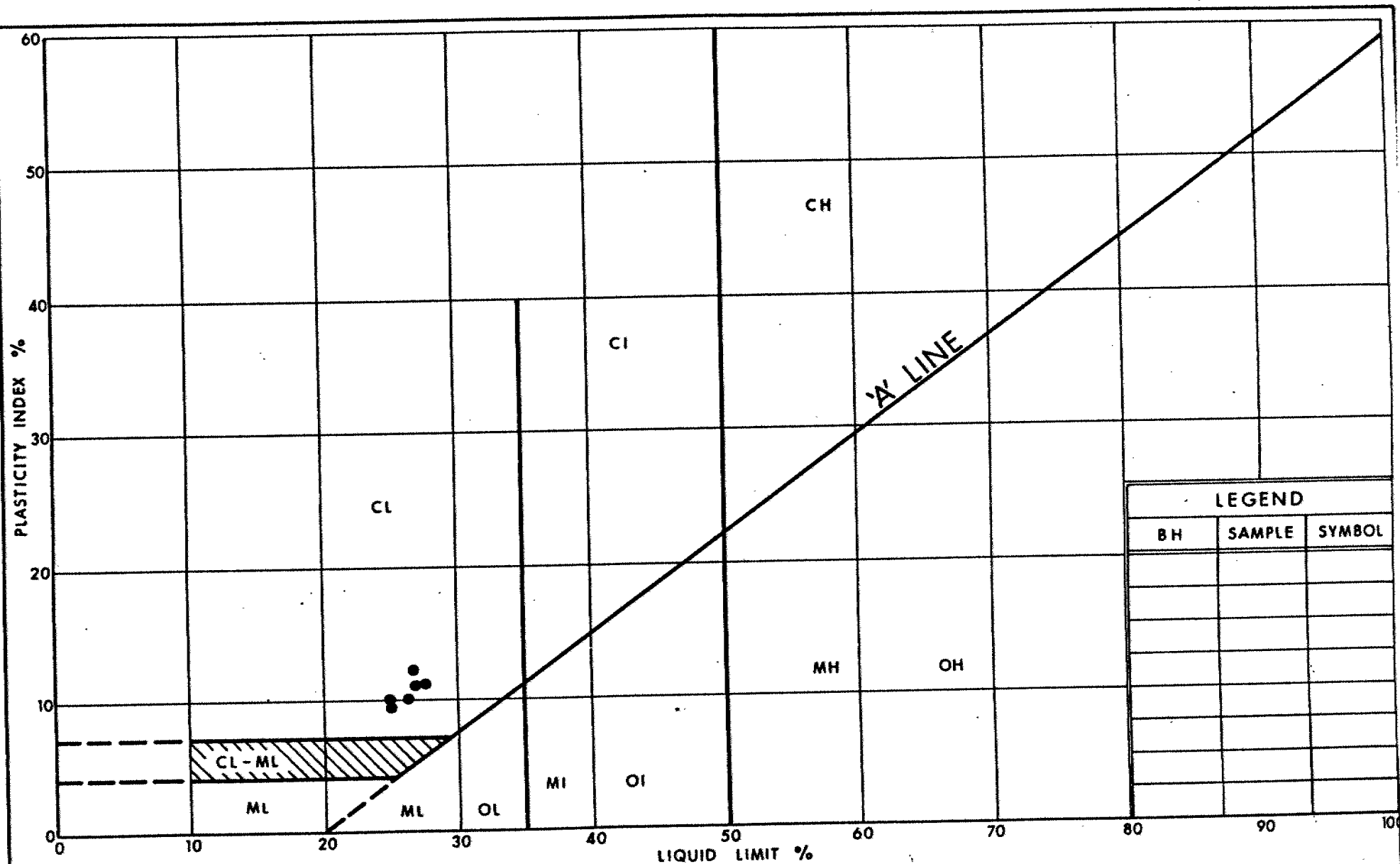
M. Devata, P. Eng.
Chief Foundation Engineer

APPENDIX

DESCRIPTION OF ROCK CORE - W.P. 199-77-12

BOREHOLE NUMBER				CORE DESCRIPTION	
	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
1	10.49-12.07	94	74	10.49-10.67	Shale (100%), red, highly weathered
				10.67-12.07	Shale (90%), red, unweathered, medium spaced joints, with siltstone (10%), green, unweathered; highly weathered shale layer 11.76 - 11.86 m
3	6.76- 8.33	95	52	7.76- 9.78	Shale (90%), red, slightly weathered to 7.06 m, becoming unweathered, medium spaced joints, with siltstone (10%), green, unweathered
	8.33- 9.78	100	100		
5	8.41- 9.88	100	72	8.41- 9.88	Shale (90%), red, unweathered, medium spaced joints, with siltstone (10%), green, unweathered
7	6.84- 8.33	97	73	6.84- 8.33	Shale (90%), red, unweathered, medium spaced joints, with siltstone (10%), green, unweathered; highly weathered zone from 8.0 - 8.05 m

* CR= CORE RECOVERY ; RQD = ROCK QUALITY DESIGNATION

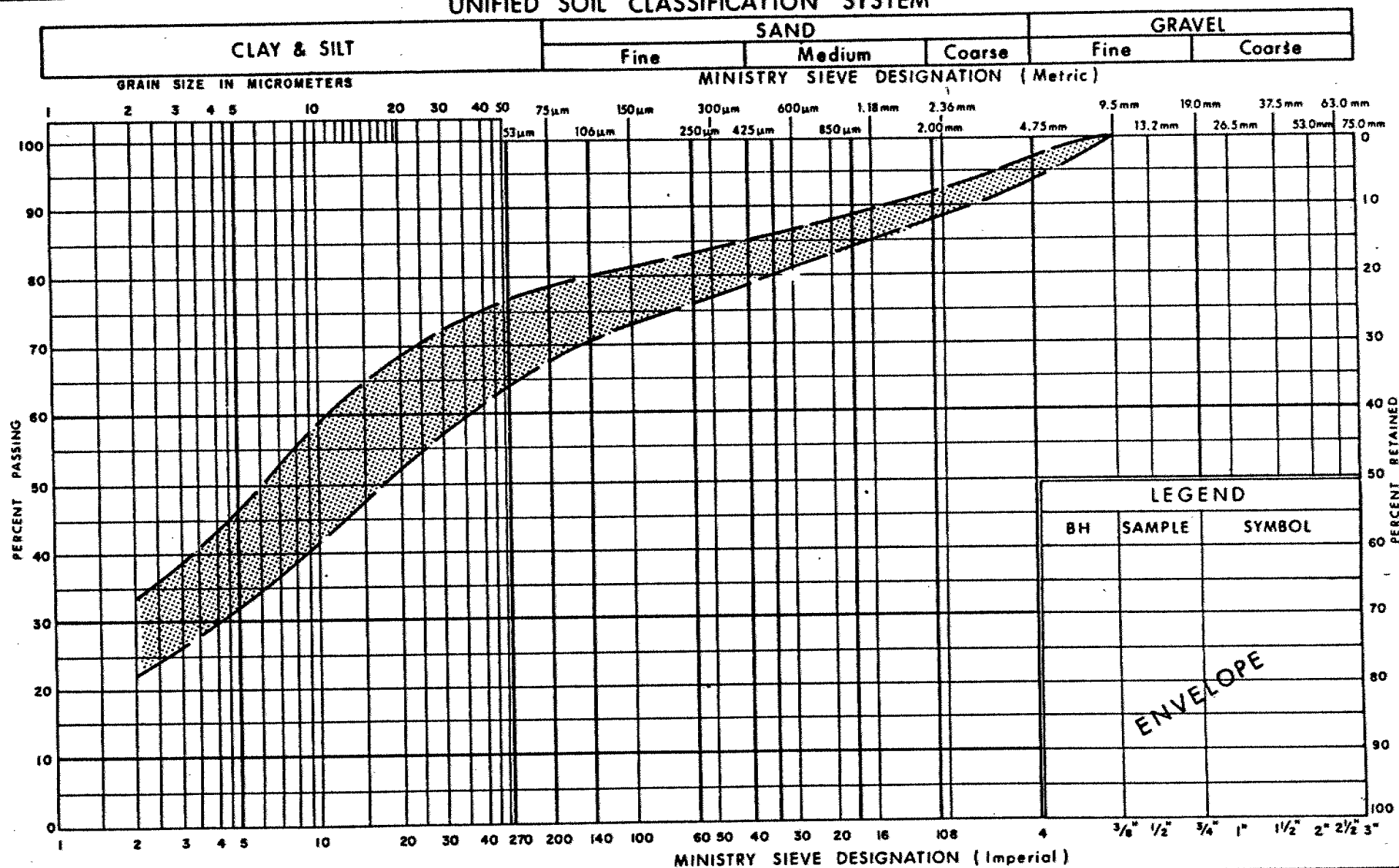


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PLASTICITY CHART

HETEROGENEOUS MIXTURE OF SILTY CLAY, SAND & GRAVEL
(Glacial Till)

UNIFIED SOIL CLASSIFICATION SYSTEM



**Ministry of
Transportation and
Communications**

GRAIN SIZE DISTRIBUTION

HETEROGENEOUS MIXTURE OF SILTY CLAY, SAND & GRAVEL
(Glacial Till)

FIG No 2

W P 199-77-12

RECORD OF BOREHOLE No 1

METRIC

W P 199-77-12 LOCATION N 4 799 934 E 277 987 ORIGINATED BY RT
DIST 4 HWY 403 BOREHOLE TYPE Solid Stem Auger & BXL Rock Coring COMPILED BY BR
DATUM Geodetic DATE 85 02 19 CHECKED BY *162*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	SHEAR STRENGTH ○ 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									
117.1	Ground Surface													
0.0	Heterogeneous Mixture of Silty Clay Sand and Gravel Stiff to Hard (Glacial Till)		1	SS	44		116							2 26 45 27
			2	SS	21									
			3	SS	17									
			4	SS	18									
			5	SS	13									
			6	SS	24									
			7	SS	29									
			8	SS	50									
			9	SS	100			30 cm						
107.7	Bedrock		10	SS	100		108							
9.4	Weathered Sound (Queenston Shale)		11	BXL RC	REC 94%		106						RQD 74%	
105.0	End of Borehole						104							
12.1	* Water Level Not Encountered													

RECORD OF BOREHOLE No 2										METRIC			
W P 199-77-12		LOCATION N 4 799 921 E 277 992				ORIGINATED BY RT							
DIST 4 HWY 403		BOREHOLE TYPE Dynamic Cone Penetration Test				COMPILED BY BR							
DATUM Geodetic		DATE 85 02 18				CHECKED BY <i>[Signature]</i>							
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					
113.4	Ground Surface												
0.0													
110.5													
2.9	End of Cone Test												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 3

METRIC

W P 199-77-12 LOCATION N 4 799 902 E 277 998 ORIGINATED BY RT
DIST 4 HWY 403 BOREHOLE TYPE Solid Stem Auger - BXL Rock Coring COMPILED BY BR
DATUM Geodetic DATE 85 02 15 CHECKED BY [Signature]

[illegible]

+3, x5: Numbers refer to Sensitivity

20
15 ϕ
10



RECORD OF BOREHOLE No 4

METRIC

W P 199-77-12 LOCATION N 4 799 890 E 278 000 ORIGINATED BY RT
DIST 4 HWY 403 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY BR
DATUM Geodetic DATE 85 02 14 CHECKED BY [Signature]

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	20					
115.5	Ground Surface												
0.0													
112.1													
3.4	End of Cone Test												



RECORD OF BOREHOLE No 5

METRIC

W P 199-77-12 LOCATION N 4 799 893 E 278 010 ORIGINATED BY RT
DIST 4 HWY 403 BOREHOLE TYPE Solid Stem Auger & BXL Rock Coring COMPILED BY BR
DATUM Geodetic DATE 85 02 14 CHECKED BY *BR*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ 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								
115.1	Ground Surface												
0.0	Fill - Silty Clay trace organics and gravel Stiff		1	SS	13		114						
114.1			2	SS	28								
1.0	Heterogeneous Mixture of Silty Clay Sand and Gravel		3	SS	26								
	Very Stiff to Hard		4	SS	37								
	Occasional Boulders		5	SS	37								
			6	SS	33								
	Grey (Glacial Till)		7	SS	73/20 cm								4 25 47 24
107.2			8	SS	100/13 cm								
7.9	Weathered Sound		9	SS	100/5 cm								
	Bedrock		10	BXL RC	REC 100%		106						RQD 72%
105.2	(Queenston Shale)												
9.9	End of Borehole						104						

RECORD OF BOREHOLE No 6

METRIC

W P 199-77-12 LOCATION N 4 799 904 E 278 004 ORIGINATED BY RT
 DIST 4 HWY 403 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY BR
 DATUM Geodetic DATE 85 02 15 CHECKED BY [Signature]

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					
112.9	Ground Surface												
0.0													
110.0													
2.9	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 7

METRIC

W P 199-77-12 LOCATION N 4 799 923 E 277 996 ORIGINATED BY RT
 DIST 4 HWY 403 BOREHOLE TYPE Solid Stem Auger - BXL Rock Coring COMPILED BY BR
 DATUM Geodetic DATE 85 02 18 CHECKED BY SO

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					
113.4	Ground Surface												
0.0	Heterogeneous Mixture of Silty Clay Sand and Gravel Very Stiff to Hard (Glacial Till)		1	SS	19								
			2	SS	20								
			3	SS	27								
			4	SS	84/	23 cm							
			5	SS	78/	23 cm							
			6	SS	72/	23 cm							
			7	SS	100/	8 cm							
107.2	Grey Reddish Green		8	SS	100/	15 cm							
6.2	Weathered Sound												
105.1	Bedrock (Queenston Shale)		9	BXL RC	REC 97%								RQD 73%
8.3	End of Borehole * Water Level not Encountered												

+3, x5: Numbers refer to
Sensitivity

20
15 ± 5 (%) STRAIN AT FAILURE
10

FOUNDATION INVESTIGATION REPORT

37

For

Hwy. 403 - Brant St. Underpass

W.P. 199-77-13, Site 10-1337-340

District 4, Burlington

INTRODUCTION

This report summarizes the factual information obtained from a foundation investigation performed at the above-mentioned site. Fieldwork consisted of ten sampled boreholes and four dynamic cone penetration tests advanced during the period 85 01 17 to 85 01 28. Bedrock was proven by obtaining up to 3.1 m of rock core in BXL size. Boring depths ranged from 11.6 m to 16.8 m and all borings were advanced utilizing track mounted auger machines.

SITE DESCRIPTION

The site is located on existing Brant St., in the City of Burlington, Regional Municipality of Halton.

At the future crossing of Hwy. 403 at Brant St. it is proposed to construct a twin cast-in-place 4-span concrete structure which will carry Brant St. over new Hwy. 403.

Brant St. is presently a four-lane urban roadway.

At the proposed crossing, preliminary grading has been carried out along the Hwy. 403 right-of-way both to the east and west of Brant St., with the most significant cut being immediately to the west of the proposed structure.

The site is located in the physiographic region known as the South Slope which is characterized in this area by a ground moraine of limited relief.

The bedrock underlying the site is a red shale with siltstone of the Queenston Formation.

SUBSURFACE CONDITIONS

General

The boundaries of the various subsoil types are shown on the Record of Borehole Sheets located in the Appendix. The locations and elevations of the borings, along with an estimated stratigraphic profile based on the borehole data, are shown on Drawing Number 1997713-A.* This report must be read in conjunction with the above-noted items.

* DWG NO 2 OF THE CONTRACT DWG'S

The subsoil conditions are fairly uniform across the site. Underlying up to 2.7 m of silty clay, some gravel and sand fill, is a heterogeneous mixture of silty clay with varying proportions of sand and gravel, and occasional cobbles and boulders. The site is underlain by a red shale with siltstone of the Queenston Formation.

The various soil types encountered are described in the following paragraphs.

FILL - Silty Clay, some Gravel and Sand

This material was encountered at all borehole locations except numbers 7 and 8. It ranged in thickness from 1.3 m at borehole 9 to 2.7 m at borehole 1. The consistency of this deposit, as determined by Standard Penetration Test 'N' values ranged from firm to very stiff.

Heterogeneous mixture of Silty Clay, Sand and Gravel (Glacial Till)

This is the predominant soil type at the site and was encountered at all borehole locations. It consists of a heterogeneous mixture of silty clay with varying proportions of sand and gravel.

The results of Atterberg Limit and water content testing are plotted on the Plasticity Chart, Figure No. 1, and are summarized as follows:

		Range	Average
Water Content	(W)%	7-23	13
Liquid Limit	(W _L)%	20-36	26
Plastic Limit	(W _p)%	13-19	16
Plasticity Index	(I _p)%	3-18	12

The results of grain size distribution tests are plotted in envelope form on Figure 2 of the Appendix.

Standard Penetration 'N' values ranged from 16 to over 100 blows per 0.3 m penetration which indicates that the consistency of this deposit ranges from very stiff to hard. Occasional cobbles and boulders were encountered throughout the deposit.

Bedrock

Bedrock was proven by obtaining up to 3.1 m of rock core in BXL size. The bedrock was encountered at depths ranging from 11.5 m to 13.8 m.

The bedrock at this site is from the Queenston Formation and consists of red shales with interbedded siltstone. The upper 1 m to 2 m of the shale is in a highly weathered condition with alternating layers of broken rock and a red silty clay material.

A detailed description of the rock cores was prepared by Mr. E. Magni, Ministry of Transportation and Communications, Geologist and his report is located in the Appendix.

Groundwater

The groundwater was found at various elevations across the site. However, the true groundwater elevation is believed to be controlled by the Highway 403 advance cut just to the southwest of the site and is assumed to be at or below elevation 122 + m.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of Messrs. R. Thomas and D. Graham, Student Specialist Engineers utilizing equipment owned and operated by Atcost Soil Drilling, Concord and Dominion Soil Investigation Ltd., Scarborough. This report was written by Mr. B. Ruck, Project Foundations Engineer and reviewed by Mr. K. Selby, Chief Foundations Engineer, (West).



P. Payer
P. Payer, P. Eng.
Sr. Foundation Engineer

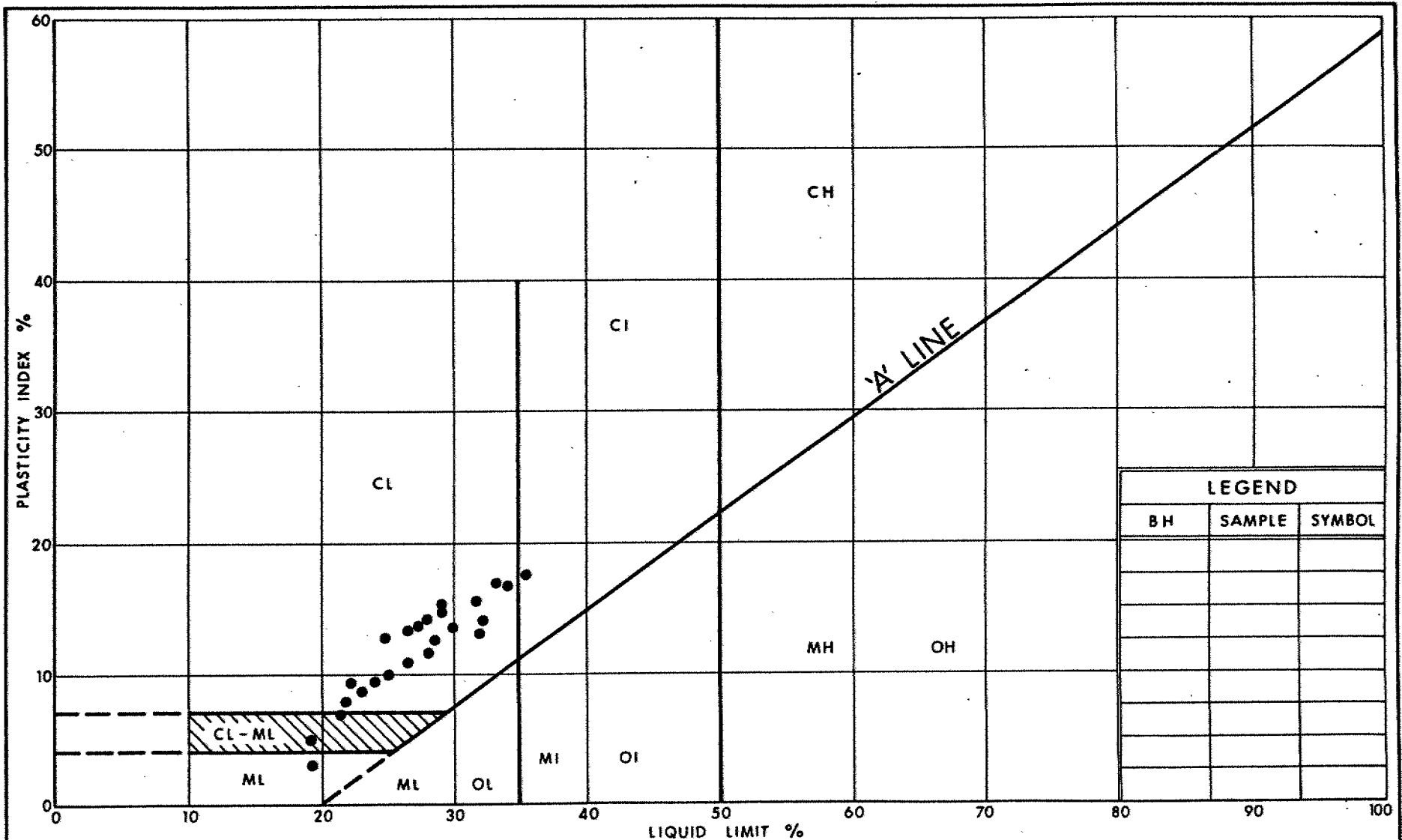
M. Devata
M. Devata, P. Eng.
Chief Foundation Engineer

APPENDIX

DESCRIPTION OF ROCK CORE - W.P. 199-77-13

BOREHOLE NUMBER				CORE DESCRIPTION	
	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
2	12.31-13.90	85	66	12.31-12.80	Shale (100%), red, moderately weathered, very closely spaced joints
				12.80-12.90	Shale (75%), red, unweathered, medium spaced joints, with siltstone (25%), green, unweathered
4	13.59-15.19 15.19-16.71	97 100	57 100	13.59-13.74	Shale (100%), red, moderately weathered, very closely spaced joints
				13.74-16.71	Shale (80%), red, unweathered, medium spaced joints, with siltstone (20%), green, unweathered, with moderately weathered layer of red shale from 14.05 m - 14.20 m
7	13.64-15.19 15.19-16.71	92 100	73 58	13.64-15.19	Shale (90%), red, unweathered, medium spaced joints, with siltstone (10%), green, unweathered
8	13.56-15.18	100	79	13.64-15.19	Shale (75%), red, unweathered, medium spaced joints, with siltstone (25%), green, unweathered
9	15.19-16.76	90	48	15.19-16.76	Shale (90%), red, unweathered, medium spaced joints, with siltstone (10%), green, unweathered

* CR = CORE RECOVERY ; RQD = ROCK QUALITY DESIGNATION



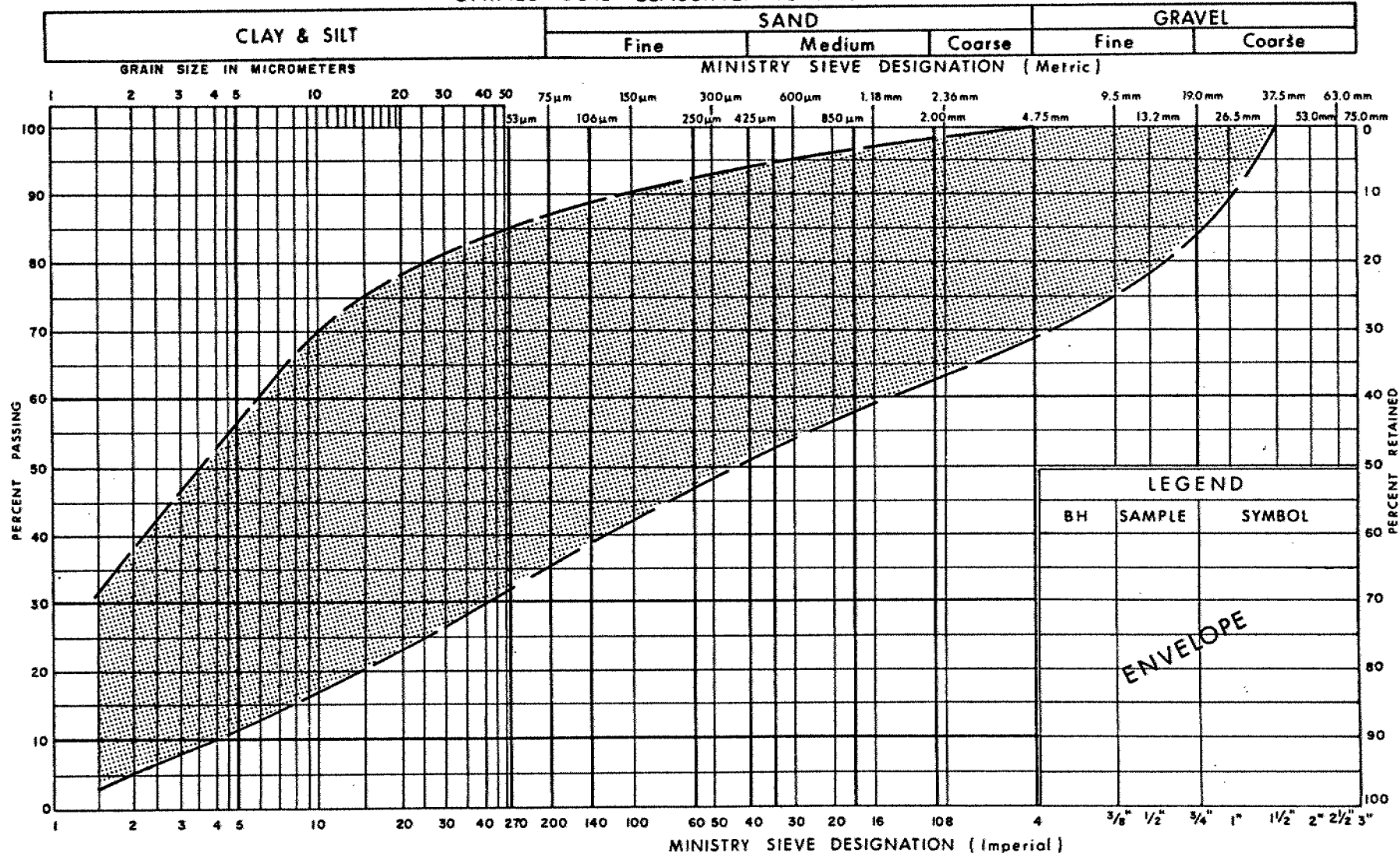
Ministry of
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Communications

PLASTICITY CHART
HETEROGENEOUS MIXTURE OF SILTY CLAY, SAND & GRAVEL
 (Glacial Till)

FIG No 1

W P 199 - 77 - 13

UNIFIED SOIL CLASSIFICATION SYSTEM



**Ministry of
Transportation and
Communications**

Ontario

GRAIN SIZE DISTRIBUTION
HETEROGENEOUS MIXTURE OF SILTY CLAY, SAND & GRAVEL
(Glacial Till)

FIG No 2

W P 199-77-13



RECORD OF BOREHOLE No 1

METRIC

W P 199-77-13 LOCATION Co-ords. N 4 800 814.5; E 277 884.0 ORIGINATED BY BR
DIST 4 HWY 403 BOREHOLE TYPE Hollow Stem Auger COMPILED BY BR
DATUM Geodetic DATE 85 01 17 CHECKED BY S

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 ● QUICK TRIAXIAL	+ FIELD VANE x LAB VANE						
130.2	Ground Surface														
0.0	Silty Clay Some Gravel and Sand Fill Stiff		1	SS	11									21 41 26 11	
			2	SS	15										
127.5			3	SS	15										
2.7	Heterogeneous Mixture of Silty Clay, Sand and Gravel Hard Glacial Till occasional cobbles and boulders		4	SS	34										
			5	SS	40										
			6	SS	70										
			7	SS	33										
			8	SS	49										
			9	SS	99										
			10	SS	100										
118.3														25 26 38 11	
11.9	Bedrock Weathered Queenston Shale	11	SS	100	6 cm										
116.7		12	SS	100	5 cm										
13.5	End of Borehole														

+3, x⁵: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 2

METRIC

W P 199-77-13 LOCATION Co-ords. N 4 800 795.0; E 277 903.0 ORIGINATED BY BR
 DIST 4 HWY 403 BOREHOLE TYPE Hollow Stem Auger - BXL Rock Coring COMPILED BY BR
 DATUM Geodetic DATE 85-01-18 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					
129.9	Ground Surface																
0.0	Silty Clay some sand and gravel Fill Stiff		1	SS	11		128										
121.5			2	SS	72		126										
2.4	Heterogeneous Mixture of Silty Clay Sand and Gravel Hard Glacial Till Occasional cobbles and boulders		3	SS	69		124										
			4	SS	35		122										
			5	SS	44		120										
			6	SS	100	28 cm											
			7	SS	100	25 cm											
118.3			8	SS	100	10 cm	118										
11.6	Bedrock Weathered Sound Queenston Shale		9	BXL RC	REC 85%		116										RQD = 66%
116.0	End of Borehole * Water Level Not Observed																

+3, x5: Numbers refer to
Sensitivity

20
15 \pm 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 3

METRIC

W P 199-77-13 LOCATION Co-ords. N 4 800 770.0; E 277 927.5
DIST 4 HWY 403 BOREHOLE TYPE Solid Stem Auger
DATUM Geodetic DATE 85 01 21
ORIGINATED BY RT
COMPILED BY BR
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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100					
129.3	Ground Surface															
0.0	Silty Clay some sand and gravel Fill		1	SS	16											
126.9	Stiff to Very Stiff															
2.4	Heterogeneous Mixture of Silty Clay Sand and Gravel		2	SS	38											
	Hard		3	SS	70											
	Glacial Till		4	SS	45											
	Occasional cobbles and boulders		5	SS	44											
			6	SS	100/23 cm											
			7	SS	100/30 cm											
117.8	Bedrock															
117.1	Weathered															
12.2	End of Borehole															
	* Water Level Not Observed															

+3, x5: Numbers refer to
Sensitivity

20
15 + 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 5

METRIC

W P 199-77-13 LOCATION Co-ords. N 4 800 720.0; E 277 977.0 ORIGINATED BY RT
DIST 4 HWY 403 BOREHOLE TYPE Solid Stem Auger COMPILED BY BR
DATUM Geodetic DATE 85 01 21 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					
127.6	Ground Surface																
0.0	Silty Clay some sand and gravel Fill		1	SS	16												
125.4	Very Stiff		2	SS	27												
2.2			3	SS	54												
			4	SS	55												
			5	SS	61												
	Heterogeneous Mixture of Silty Clay Sand and Gravel		6	SS	41												
	Very Stiff to Hard		7	SS	19												
	Glacial Till																
	Occasional cobbles and boulders		8	SS	43												
			9	SS	100/18 cm												
			10	SS	100/23 cm												
115.8																	
11.8	Bedrock Weathered Queenston Shale		11	SS	100/0 cm												
113.9			12	AS													
13.7	End of Borehole																
	* Water Level Observed 2 hours after completion																

+3, x5: Numbers refer to
Sensitivity

20
15 \div 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 6

METRIC

W P 199-77-13 LOCATION Co-ords. N 4800 693.0; E 277 963.5 ORIGINATED BY DG
 DIST 4 HWY 403 BOREHOLE TYPE Solid Stem Auger COMPILED BY BR
 DATUM Geodetic DATE 85 01 25 CHECKED BY LD

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			SHEAR STRENGTH kPa						
128.1	Ground Surface													
0.0	Silty Clay some sand and gravel Fill		1	SS	16									
126.4	Very Stiff		2	SS	37									
1.7			3	SS	44									
			4	SS	25									
	Heterogeneous Mixture of Silty Clay Sand and Gravel		5	SS	30									
	Very Stiff to Hard		6	SS	16									
	Glacial Till		7	SS	19									
			8	SS	33									
			9	SS	100/30 cm									
			10	SS	79/23 cm									
116.4	Bedrock - Weathered		11	SS	100/5 cm									
115.9														
12.2	End of Borehole													
	* Water Level Not Observed													

*3, *5: Numbers refer to
Sensitivity

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



RECORD OF BOREHOLE No 7

METRIC

W P 199-77-13 LOCATION Co-ords. N 4 800 708.5; E 277 941.5 ORIGINATED BY RT
DIST 4 HWY 403 BOREHOLE TYPE Solid Stem Auger & BXL Rock Coring COMPILED BY BR
DATUM Geodetic DATE 85 01 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	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 (%)					
129.0	Ground Surface																
0.0	Heterogeneous Mixture of Silty Clay Sand and Gravel Very Stiff to Hard Glacial Till		1	SS	50												
			2	SS	55												
			3	SS	37												
			4	SS	27												
			5	SS	39												
			6	SS	1007	25 cm											
			7	SS	1007	23 cm											
			8	SS	1007	23 cm											
116.5	Bedrock																
12.5	Weathered Sound		9	BXL RC	REC 92%										RQD = 73%		
	Queenston Shale		10	BXL RC	REC 100%										RQD = 58%		
112.3																	
16.7	End of Borehole																

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 8

METRIC

W P 199-77-13 LOCATION Co-ords. N 4 800 735.5; E 277 916.0 ORIGINATED BY RT
DIST 4 HWY 403 BOREHOLE TYPE Solid Stem Auger & BXL Rock Coring COMPILED BY BR
DATUM Geodetic DATE 85 01 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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
129.9	Ground Surface																
0.0	Heterogeneous Mixture of Silty Clay Sand and Gravel Very Stiff to Hard Glacial Till Occasional cobbles and boulders		1	SS	52												
			2	SS	73												
			3	SS	36												
			4	SS	29												
			5	SS	31												
			6	SS	75												
			7	SS	1007												
117.6	Bedrock Weathered Sound Queenston Shale		8	SS	1007												
12.3			9	BXL RC	REC 1002												
114.7	End of Borehole * Water Level at Completion																
15.2																	

RECORD OF BOREHOLE No 9										METRIC				
W P 199-77-13		LOCATION Co-ords. N 4 800 759.0; E 277 892.0		ORIGINATED BY RT										
DIST 4 HWY 403		BOREHOLE TYPE Solid Stem Auger & BXL Rock Coring		COMPILED BY BR										
DATUM Geodetic		DATE 85 01 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	SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					
130.4	Ground Surface													
0.0	Silty Clay													
129.1	some sand and gravel		1	SS	21									
1.3	Fill - Very Stiff		2	SS	47									
			3	SS	66									
	Heterogeneous Mixture of Silty Clay Sand and Gravel		4	SS	27									
	Very Stiff to Hard		5	SS	37									
	Glacial Till		6	SS	37									
	Occasional cobbles and boulders		7	SS	65									
			8	SS	100									18 22 39 21
			9	SS	100	28 cm								
117.4			10	SS	100	8 cm								
13.0	Bedrock													
	Weathered Sound													
	Queenston Shale		11	BXL RC	REC 90%									RQD = 48%
113.6														
16.8	End of Borehole													
	* Water Level Upon Completion													

+3, x5 : Numbers refer to Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 10

METRIC

W P 199-77-13 LOCATION Co-ords. N 4 800 780.5; E 277 871.5 ORIGINATED BY RT
DIST 4 HWY 403 BOREHOLE TYPE Solid Stem Auger COMPILED BY BR
DATUM Geodetic DATE 85 01 23 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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					
130.3	Ground Surface													
0.0	Silty Clay some sand and gravel Fill Firm		1	SS	9		130							
128.2			2	SS	8		128							
2.1			3	SS	42									
			4	SS	51									
			5	SS	37									
			6	SS	40									
			7	SS	23									
			8	SS	51									
			9	SS	100/	28 cm								
			10	SS	100/	15 cm								
			11	SS	100/	15 cm								
			12	SS	100/	8 cm								
116.5														
13.8	End of Borehole						116							
	* Water Level 2 hours after Completion													

OFFICE REPORT ON SOIL EXPLORATION

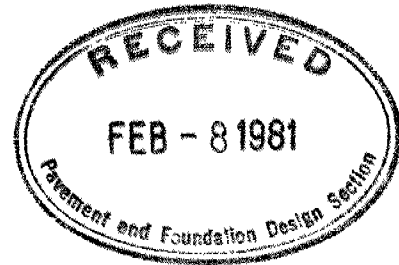
*3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10



Golder Associates

CONSULTING GEOTECHNICAL AND MINING ENGINEERS



REPORT
TO

MINISTRY OF TRANSPORTATION
AND COMMUNICATIONS

FOUNDATION INVESTIGATION
PROPOSED OVERPASS BRIDGES AT Q.E.W./
HWY. 403

W.P. 83-74-28 } SITE 10-32A
W.P. 83-74-29 } DISTRICT 4
CONT 91-22

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Mississauga, Ontario

January, 1981

801-1341

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ABSTRACT

A subsurface investigation was carried out by Golder Associates for the Ministry of Transportation and Communications at the site of two proposed overpass bridges on the QEW/403 Interchange in Burlington, Ontario.

In summary, the borings indicate that stiff to hard clayey silt fill overlies a hard clayey to sandy silt (residual soil) stratum which overlies Queenston shale bedrock at depths between 1.5 and 2.3 m below existing ground surface. The shale bedrock is highly weathered for the top two metres. Groundwater levels measured during the investigation were at or just above the fill/residual soil contact and generally follow the surface topography.

The proposed structures may be founded in the natural soil or in competent bedrock. Perched abutments placed within the embankment fill may be adopted. Depending on the tolerance of the proposed structures to differential settlement these abutments may be placed directly on specially prepared fill or founded on piles driven through the embankment and bearing on bedrock.

1.0 INTRODUCTION

Golder Associates have been retained by the Ministry of Transportation and Communications (letter dated December 5, 1980) to carry out a foundation investigation for two proposed overpass bridges on the QEW/403 Interchange in Burlington, Ontario (overall W.P. 837407).

The purpose of the investigation was to determine the subsurface conditions at the site and based on these data, to provide engineering recommendations for the geotechnical design of the foundations for the proposed structures.

The investigation was carried out, and this report was prepared, in accordance with Golder Associates' letter, dated December 23, 1980.

2.0 DESCRIPTION OF PROJECT

Details of the project were provided during a meeting between Mr. Selby of the Ministry of Transportation and Communications, and Messrs. Davis and Busbridge of Golder Associates on December 15, 1980. Additional details were provided on two plans titled "Bridge Site, Proposed Northbound QEW Underpass at Ramp QEW-S to Hwy. 403" designated Site 10-320, W.P. 837428-A, dated September 30, 1980, and "Bridge Site, Proposed Southbound QEW Underpass at Ramp QEW-S to Hwy. 403" designated Site 10-321, W.P. 837429-A, dated October 1, 1980, and in an M.T.C. memorandum dated October 27, 1980. It is understood that the above mentioned projects form part of overall W.P. 837407.

It is understood that at Site 10-320, the proposed bridge will be a four span post-tensioned type with spans of approximately 22 m, 45 m, 39 m and 22 m. It will allow for QEW northbound traffic to proceed westerly along Hwy. 403. The centre column is to be located at the median of the future QEW.

At Site 10-321 it is understood that the proposed bridge will be a three span post-tensioned type with spans of approximately 20 m, 40 m and 20 m. It will allow for traffic carried by the previous bridge deck to overpass the future QEW southbound lanes and proceed westerly along Hwy. 403.

The approximate locations of the footings were shown in red on the two plans provided, along with profiles of both QEW and the ramps under consideration in this area.

3.0 SITE AND GEOLOGY

The proposed bridges are to be located along the QEW, south of the North Service Road and west of Brant Street in the City of Burlington, Ontario. The topography at the site is generally flat lying having an elevation about 106 m (Geodetic). Immediately to the north of the site the land rises towards the Niagara Escarpment.

The site is located in the physiographic region known as the Iroquois Plain, consisting of a narrow strip of land along the shores of the present Lake Ontario. This level plain was formed by post-glacial Lake Iroquois which then occupied the Lake Ontario basin. In the Burlington area the surficial soils in this plain consist of beach sands, clayey silt till and/or residual red clayey silt derived from weathering of the underlying Queenston shale bedrock. The Queenston shale formation consists of thinly bedded red clay shale with occasional bands of grey limestone.

4.0 INVESTIGATION PROCEDURE

The field work for this investigation was carried out between December 22 and 31, 1980. The elevations of the boreholes were determined on January 5, 1981. During this time nine boreholes were put down at the two sites (Drawings 837428-A and 837429-A) using a Type 5.3.i drillrig supplied and operated by Master Soil Investigations Ltd., of Toronto, a specialist drilling contractor. Within the overburden soils the boreholes were advanced with solid stem augers. In each

boring, standard penetration tests were carried out at 0.76 m intervals of depth, and samples were obtained using a standard 50 mm O.D. split spoon sampler, which was advanced by a 63.5 kg mass falling freely for 0.76 m. In each boring, bedrock was cored for depths of between 2.8 m to 3.8 m in BXL size. Details of the drilling and sampling operations are summarized on the Record of Borehole sheets. A filtered standpipe was sealed into each boring to allow monitoring of the groundwater level.

The field work was supervised throughout by a member of Golder Associates' engineering staff, who located the borings in the field, cleared underground services, directed the drilling and sampling operations, logged the borings and cared for the samples. The borehole locations were established by tape measurement. The ground surface elevations at each boring was determined relative to an M.T.C. survey monument (Drawing 837428-A). The elevation of this control point was provided by a member from the M.T.C. staff on January 8, 1981. It is understood that all ground surface elevations are referred to Geodetic datum.

Following field identification and logging, all the samples obtained during the investigation were placed in air-tight containers and brought to our laboratory where they were examined in detail. Representative samples of the soil were tested to determine their index properties.

5.0 SUBSURFACE CONDITIONS

The detailed stratigraphy encountered in each of the boreholes together with the results of laboratory tests carried out on representative samples of the soil strata are given on the attached Record of Borehole sheets and on Figures 1 to 3. The locations of the boreholes and the simplified stratigraphy at the boreholes are shown on Drawings 837428-A and 837429-A. It should be noted that the stratigraphic boundaries indicated on the borehole logs and longitudinal sections are inferred from a transition from one soil type

to another and do not necessarily indicate an exact plane of geologic change. Further, the subsurface conditions may vary between boreholes.

5.1 Site 10-320

At the locations of Boreholes 5, 6 and 8, up to 0.3 m of topsoil was encountered at ground surface. A layer of granular material comprising crushed stone (sand and gravel sizes) was encountered at Borehole 7 and extends to a depth of 1.4 m (Elev. 104.8 m). This material forms part of the shoulder of the existing Highway 403 exit ramp to the QEW. The topsoil at Boreholes 5, 6 and 8, the granular fill at Borehole 7 as well as ground surface at Borehole 9 are underlain by a layer of clayey silt containing some sand and gravel, pieces of red brick and occasional thin lenses of black organic matter. This fill varies in thickness from 0.6 m at Boreholes 5 to 2.0 m at Borehole 7. The fill is underlain by hard (N* values greater than 30) clayey silt containing a trace of sand and gravel to sandy silt containing some gravel, with red shale fragments throughout.

The clayey silt material has a grain size distribution (Figures 1 and 2) similar to that of a glacial till. However, the coarser fraction of the soil is angular and easily friable. This material has the characteristics of a residual soil (soil material with the original texture, structure and mineralogy of the rock completely destroyed) rather than the matrix of a glacial till. It extends to a depth of about 2.3 m (between Elev. 100.1 m to 103.2 m) below ground surface except at Borehole 7 where it extends to 4.4 m (Elev. 101.8 m) below ground surface. The fill has a grain size distribution similar to that of the residual soil (Figure 1 - BH7, SA 3) and is probably local material placed during previous construction activities.

The water content of the sandy silt is about 10 per cent and that of the clayey silt is about 17 per cent. Both

*N - Standard Penetration Resistance - See Explanation of Terms, Appendix A.

materials (forming the residual soil) exhibit low plasticities with liquid limits between 16 to 22 per cent and a plasticity index of about 2 (Figure 3). The residual soil encountered at Boreholes 5 and 9 is more granular (Figure 2) than that of Boreholes 6, 7 and 8, possibly due to it containing more weathered shale fragments. This material is underlain by highly weathered to faintly weathered, reddish brown, weak to strong Queenston shale. The shale is irregularly banded with grey limestone layers about 80 mm in thickness and an occasional thin seam of red clay. The core recovery was generally in excess of 70 per cent and the Rock Quality Designations (RQD) lies between zero and 80 per cent, the higher quality being recorded for core recovered about 2 m below the overburden/bedrock interface.

As is evidenced from the profile shown on Drawing 837428-A ground surface and the various stratigraphic units slope gently from north (BH 5) to south (BH 9). The top surface of the residual soil also slopes towards the south but is more erratic due to the surface having been changed by previous construction activities and fill placement. The elevation of Borehole 7 is higher than the other boreholes in the same general area due to it being located near the southern shoulder of the exit ramp from Hwy. 403.

The groundwater surface measured in the standpipes also slopes towards the south generally following the ground surface topography.

5.2 Site 10-321

At the location of Boreholes 1 to 4 the ground surface is underlain by between 0.12 and 0.36 m of topsoil. At Boreholes 3 and 4, the topsoil overlies a layer of fill composed of clayey silt containing some sand and gravel, pieces of red brick and occasional thin lenses of black organic matter. The fill extends to a depth of 1.1 and 0.5 m (Elev. 104.9 and 105.1 m) below ground surface at the location of these two boreholes. The topsoil at Boreholes 1 and 2 and the fill at

Boreholes 3 and 4 is underlain by between 0.7 and 1.6 m of stiff to hard (N values 17 to 39) reddish brown clayey silt containing a trace of sand and gravel and numerous red shale fragments, and is considered to be residual soil. The residual soil was penetrated to about 1.5 to 1.8 m (Elev. 103.8 to 104.7 m) below ground surface at which depths refusal to augering was encountered. The higher 'N' values given on the Record of Borehole sheets and on the profile shown on Drawing 837429-A were obtained at the overburden/bedrock contact.

The water content of the residual soil lies between 11 and 16 per cent which is below the plastic limit of the material and indicative of a heavily overconsolidated soil. The material exhibits low plasticity with a plasticity index of about 10 (Figure 3).

Bedrock was extracted by BXL rock coring techniques. The bedrock was found to be a highly weathered to faintly weathered at depth, reddish brown, weak to strong at depth, Queenston shale. The shale is irregularly banded with grey limestone layers about 80 mm in thickness and is occasionally intercepted by thin seams of red clay. The core recovery was about 73 per cent and the RQD was between zero and 60 per cent and generally below 50 per cent. This indicates that the shale bedrock is of generally poor to fair quality.

The groundwater level measured within the standpipes slopes towards the south, generally following the surface topography. Although the water level is indicated as being higher at Borehole 3 than at Borehole 2 this may be due to an interceptor ditch located near Borehole 2 thereby depressing the water level in this area.

6.0 DISCUSSION AND RECOMMENDATIONS

The recommendations for the geotechnical aspects of design of the proposed structures, together with the comments on the construction aspects of the work contained

in this section of the report are for the guidance of the design engineer only. Contractors bidding on or undertaking the works should make their own interpretation of the factual information provided as it affects their proposed construction methods, equipment selection, scheduling and the like.

6.1 Bridge Foundations

The natural soils and rock found at the site are suitable for the support of approach embankments and bridge foundations. Depending on the most economical proportioning of footing dimensions and excavation requirements, together with the tolerance of the proposed structure to differential settlement, various options may be considered.

6.1.1 Bearing Pressure - Site 10-320

At Site 10-320 the bridge may be founded on shallow spread footings placed in the hard natural residual soil and/or weathered shale. An allowable bearing pressure of 320 kPa may be used for the design of footings placed at least 2 m into the natural residual soil and/or weathered shale bedrock which underlie the site between elevation 102.3 m (BH 5) and 99.4 m (BH9).

As an alternative to founding the proposed structure in the residual soil and/or weathered shale, consideration should be given to carrying the footings to competent shale bedrock which should be encountered about 2 m below the surface of the shale, that is, at approximately between elevations 101.6 m (BH 6) and elevation 99.1 m (BH 9). An allowable bearing pressure of 640 kPa may be used for design of footings placed in the more competent shale.

6.1.2 Bearing Pressures - Site 10-321

The bridge structure at this site may be founded on shallow spread footings founded at least 2 m into the hard natural residual soil and/or weathered shale which underlies

the site. An allowable bearing pressure of 320 kPa may be used for the design of footings placed at least 2 m into the natural residual soil and/or weathered shale bedrock.

As an alternative to founding the proposed structure in the residual soil and/or weathered shale, the footings may be founded on competent shale bedrock which should generally be encountered at about elevation 103 m. An allowable bearing pressure of 640 kPa may be used for design of footings placed in competent shale. It should be stressed that at the location of BH 1 the highly weathered shale bedrock extends down to at least elevation 101.7 m and was not penetrated. Footings extending to competent shale bedrock will have to be founded at a lower elevation in this area.

6.2 Special Considerations for Abutments

Consideration should be given to the effect of high (up to 10 m) approach embankment on the settlement of bridge abutments. The embankment loads are apt to induce settlement of the underlying soils which in turn drags down the abutments. Since the bridge piers are not subjected to the same loading, the settlements are largely differential.

6.2.1 Abutments on Spread Footings

Where abutments are placed on the residual soil or highly weathered shale bedrock it is anticipated that a differential settlement of up to 50 mm could develop between the abutment and the adjacent bridge pier. This can be reduced to less than 25 mm by ensuring that footings are taken down to the competent shale as discussed in 6.1.1 and 6.1.2.

Where the abutments are required to act as retaining walls the lateral earth loads will depend on the type and method of placement of the fill materials. The following recommendations are made in respect to the design of the

abutment retaining walls:

- (i) Selected granular fill, such as M.T.C. Granular 'B' should be used as backfill immediately behind the structures. The granular fill should be placed in the wedge-shaped zone defined by a 45 degree line extending up and back from the rear face of the structures' footings;
- (ii) All granular fill should be compacted in 200 mm thick lifts to 95 per cent of the standard Proctor dry density of the material. However, heavy compaction equipment should not be used behind any structure within a lateral distance equal to the current height of the fill above the base of the structure;
- (iii) Provided that the above criteria are satisfied, a coefficient of active earth pressure (K_a) of 0.3 may be used in computing lateral earth pressures, if an outward deflection of approximately 1/2 per cent of the wall height can be tolerated at the bridge bearings. If this amount of deflection cannot be absorbed, than an at-rest coefficient of earth pressure (K_o) equal to 0.5, should be used in calculating the lateral earth pressures. A coefficient of friction less than or equal to 0.55 may be assumed between the concrete footings and the bedrock. A bulk unit weight of 20 kN/m^3 may be assumed for the Granular 'B' backfill;
- (iv) An adequate drainage system should be provided behind the abutments to prevent build-up of hydrostatic forces. The drainage system should include a properly designed filter to prevent clogging of the pipes. Provision should be made to allow cleaning or rodding of the pipes, should they become clogged.

6.2.2 Perched Abutments

As an alternative to abutments on spread footings consideration could be given to adopting perched abutments placed within the embankment fill. Depending on the degree of continuity of the bridge deck structure and therefore its tolerance to differential settlement these abutments can be supported on specially prepared embankment material or on piles driven through the embankment fill.

Where no piling is used it will be necessary to remove all existing fill and to replace with granular fill, compacted to a minimum of 100 per cent of the Standard Proctor density. The granular material should extend from the underside of the abutment down to the natural soil at a slope of 2 horizontal to 1 vertical. Material within 1.5 m of the underside of the abutment should conform to M.T.C Granular 'B' specification. An allowable bearing pressure of 200 kPa may be used for the design of the abutment footing provided it is placed a minimum of 3 m from the face of the slope measured at the founding level. Where the bridge structure cannot tolerate a differential settlement of 75 mm between abutment and pier it is recommended that perched abutments are founded on piles driven through the embankment fill.

The piles should be founded on the shale bedrock. Steel H-pile section HP310 x 79 driven to a set of 20 blows/25 mm using a driving energy of at least 54 kilo joules per blow will be capable of supporting a working load of 700 kN per pile.

6.3 General Considerations

All footings should be placed a minimum 1.2 m below final exterior grade for frost protection.

To ensure that the footings are placed on relatively undisturbed natural residual soil, weathered shale or

competent bedrock, it is recommended that the base of all footing excavations be inspected by a qualified geotechnical engineer prior to placement of any concrete.

6.4 Comments on Construction

It is anticipated that it will be possible to excavate the top 4 m of shale by ripping although progress may be slow where bands of limestone are encountered. The ingress of water into the excavations must be prevented as water will soften the shale. Further, the foundations should not be exposed any more than necessary and should not be left open overnight. A coating of working concrete should be applied to the foundation surface as soon as possible after excavation.

In order to allow construction of footings placed below the groundwater level, suitable shoring of the excavations will be required. The control of groundwater inflow by methods such as pumping from sumps will also be required.

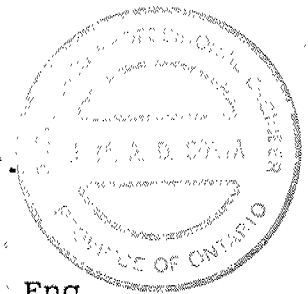
GOLDER ASSOCIATES

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J. R. Busbridge, P. Eng.



JMC:JRB:ee
801-1341

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/0.3m)	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 (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

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

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 = $\frac{c_u}{\tau_r}$

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

W P 837429-A LOCATION Co-ords 4,799,746N; 278,076 E (STA 8+ 921) ORIGINATED BY A.H.T.
DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.H.C.
DATUM Geodetic DATE December 22, 1980 CHECKED BY J.S.C.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
106.24	Ground Level																
0.00																	
105.88	Topsoil																
0.36	Clayey Silt with shale fragments (Residual soil). Hard.		1	SS	39												0 6 70 24
104.72	Red and Greenish Grey.		2	SS	50/127 mm												
1.52	Shale Bedrock. Highly weathered reddish brown, fine grained, weak, irregularly ban- ded with grey lime- stone layers about 80mm thick. 76mm clay seam at Elev. 103.3 m.		3	R.C. BXL	95%												RQD 31%
			4	RC BXL	89%												RQD 9%
101.70																	
4.54	End of Borehole.																W.L. elev 105.17 on Jan.5, 1981

RECORD OF BOREHOLE No. 2

W P 837429-A LOCATION Co-ords 4,799,727 N; 278,084 E (STA 8+942.5) ORIGINATED BY A.H.T.
DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
DATUM Geodetic DATE December 23, 1980 CHECKED BY J. Smith

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100		
106.33	Ground Level													
106.09	Topsoil													
0.24	Clayey Silt, some shale fragments (residual soil).		1	SS	17									
	Very Stiff.													
104.50	Reddish Brown.		2	SS	25									
1.83	Shale bedrock, highly weathered, reddish brown, fine grained, weak.		3	RC BXL	91%									
103.28	32mm clay seam at Elev. 103.7 m.													
3.05	Shale Bedrock. Faintly weathered reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		4	RC BXL	100%									
101.21			5	RC BXL	100%									
5.12	End of Borehole.													

+3, x5: Numbers refer to
Sensitivity

20
15 → 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No. 3

W P 837429-A LOCATION Co-ords 4,799,692 N; 278,102 E (STA 8+982.5) ORIGINATED BY A.H.T.
DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
DATUM Geodetic DATE December 23, 1980 CHECKED BY J. L. C.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH										WATER CONTENT (%)		
								20 40 60 80 100										10 20 30		
105.96	Ground Level																			
0.00	Topsoil																			
0.12	Clayey Silt (Fill).																			
	Hard.																			
104.89	Brown to Black.																			
1.07	Clayey Silt, with shale fragments (Residual Soil)		1	SS	17															
104.19	Hard. Reddish brown.		2	SS	115/279															
1.77	Shale Bedrock. Highly weathered. Reddish brown, fine grained, weak.		3	RC. BXL	73%															
103.16																				
2.80	Shale Bedrock. Faintly weathered, reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		4	RC BXL	92%															
			5	RC BXL	100%															
101.33																				
4.63	End of Borehole.																			

RECORD OF BOREHOLE No.4

W P 837429-A LOCATION Co-ords 4,789,673 N; 278,111 E (STA 9+002.5) ORIGINATED BY A.H.T.
 DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
 DATUM Geodetic DATE December 23 & 24, 1980 CHECKED BY J. G. F.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
105.56	Ground Level																
0.00	Topsoil																
0.12	Clayey Silt (Fill).																
105.10	Stiff, Brown.																
0.46	Clayey Silt, some gravel and shale fragments (Residual Soil).		1	SS	23												
103.79	Hard, Reddish Brown.		2	SS	84												
1.77	Shale Bedrock.																
103.33	Moderately Weathered.			Rc													
2.23	Shale Bedrock. Faintly weathered, reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		3	BXL	98%												
			4	Rc													
				BXL	97%												
100.96																	
4.60	End of Borehole.																

+3, x3 : Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No. 5

W P 83742B-A LOCATION Co-ords. 4,799,633 N; 278,130 E (STA 9+047) ORIGINATED BY A.H.T.
 DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
 DATUM Geodetic DATE December 29, 1980 CHECKED BY J. V. C.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
105.42	Ground Level																
0.00	Topsoil						Seal										
105.12	Clayey to Sandy Silt (Fill).		1	SS	15		105										
104.65	Stiff Red to Dark Brown		2	SS	28												
0.91	Sandy silt, some gravel, trace clay (Residual Soil).					Backfill	104										
			3	SS	76												16 34 42 8
103.27	Dense. Reddish Brown.		4	SS	55/100 mm		103										RQD 0%
2.29	Shale Bedrock. Slightly weathered. Reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		5	RC BXL	11%		102										RQD 48%
			6	RC BXL	97%		101										RQD 73%
101.29	Shale Bedrock. Faintly weathered reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		7	RC BXL	101%	Pea Gravel	100										W.L. Elev. 104.87 on Jan. 5/81
99.68	End of Borehole.						99										

RECORD OF BOREHOLE No.6

W P 837428-A LOCATION Co-ords. 4,799,610N; 278,139E (STA. 9+071) ORIGINATED BY A.H.T.
 DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
 DATUM Geodetic DATE December 29, 1980 CHECKED BY J. J. L.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
105.47	Ground Level																
0.0	Topsoil																
0.15	Clayey to Sandy Silt, some gravel (Fill).		1	SS	17	Seal	105										
			2	SS	18	Backfill	104										
103.67	Compact, Brown.		3	SS	38												
1.80	Clayey Silt, some gravel (Residual Soil).																
103.13	Hard. Reddish Brown.					Seal											
2.34	Shale Bedrock. Moderately weathered reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		4	SS	70/152	Seal	103										
			5	RC	98%		102										
101.63				BXL													
3.84	Shale Bedrock, Faintly weathered reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		6	RC	100%	Pea	101										
				BXL		Gravel											
99.80							100										
5.67	End of Borehole.						99										

RECORD OF BOREHOLE No.7

W P 837428-A LOCATION Co-ords. 4,799,575N; 278,151E (STA. 9+108) ORIGINATED BY A.H.T.
DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
DATUM Geodetic DATE December 30, 1980 CHECKED BY J.H.C.

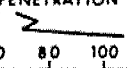
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100									
								SHEAR STRENGTH					10 20 30				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE									
106.22	Ground Level																GR SA SI CL
0.0	Crushed Stone (Sand and Gravel sizes) (Fill).						Seal	106									
104.85	Very Dense, Brown.		1	SS	59			105									
1.37	Clayey Silt, some sand, trace gravel (Fill).		2	SS	44		Backfill	104									2 20 57 21
	Stiff to Hard.		3	SS	13			103									
102.84	Brown.		4	SS	40			102									
3.38	Clayey Silt, some sand, trace gravel and shale fragments (Residual Soil).		5	SS	60/152		Seal	102									
101.80	Hard. Reddish Brown.		6	SS	60/152			101									RQD 0%
4.42	Shale Bedrock. Highly weathered. Reddish brown. Fine grained. Weak.		7	RC BXL	39%			100									RQD 53%
100.73	Shale Bedrock. Moderately weathered reddish brown, fine grained, strong. Irregular banded with grey limestone layers about 80 mm thick.		8	RC BXL	120%			99									RQD 41%
5.49	Shale Bedrock. Faintly weathered. Reddish brown with irregular grey limestone bands.		9	RC BXL	78%			98									RQD 86%
99.15	Fine grained. Strong.		10	RC BXL	86%												W.L. elev. 102.44 on Jan. 5/81
7.07	End of Borehole.																
98.08																	
8.14																	

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No.8

W P 837428-A LOCATION Co-ords. 4,799,531N; 278,161E (STA. 9+152) ORIGINATED BY A.H.T.
 DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
 DATUM Geodetic DATE December 29 & 30, 1980 CHECKED BY J.L.F.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH					WATER CONTENT (%)				
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	x LAB VANE						
103.01	Ground Level																
0.00																	
102.70	Topsoil																
0.31	Sandy Silt to Clayey Silt (Fill). Very Stiff. Brown.																
102.06			1	SS	35		102										
0.95	Sandy Silt to Clayey Silt with gravel (Residual Soil). Hard. Reddish Brown.		2	SS	65/152												
101.18																	
1.83	Shale Bedrock. Highly weathered. Reddish brown with irregular grey limestone bands about 80 mm thick. Fine grained. Weak.		3	RC BXL	44%		101									RQD 0%	
			4	RC BXL	100%		100									RQD 34%	
99.11																	
3.90	Shale Bedrock. Slightly weathered. Reddish brown with irregular grey lime- stone bands about 80 mm thick. 75 mm clay seam at Elev. 99.1 m. Fine grained. Strong.		5	RC BXL	99%		99									RQD 45%	
			6	RC BXL	100%											RQD 100%	
97.68			7	RC BXL	100%		98									RQD 100%	
5.33	End of Borehole.						97									W.L. elev. 102.13 on Jan. 5/81	

*3, *5: Numbers refer to
Sensitivity

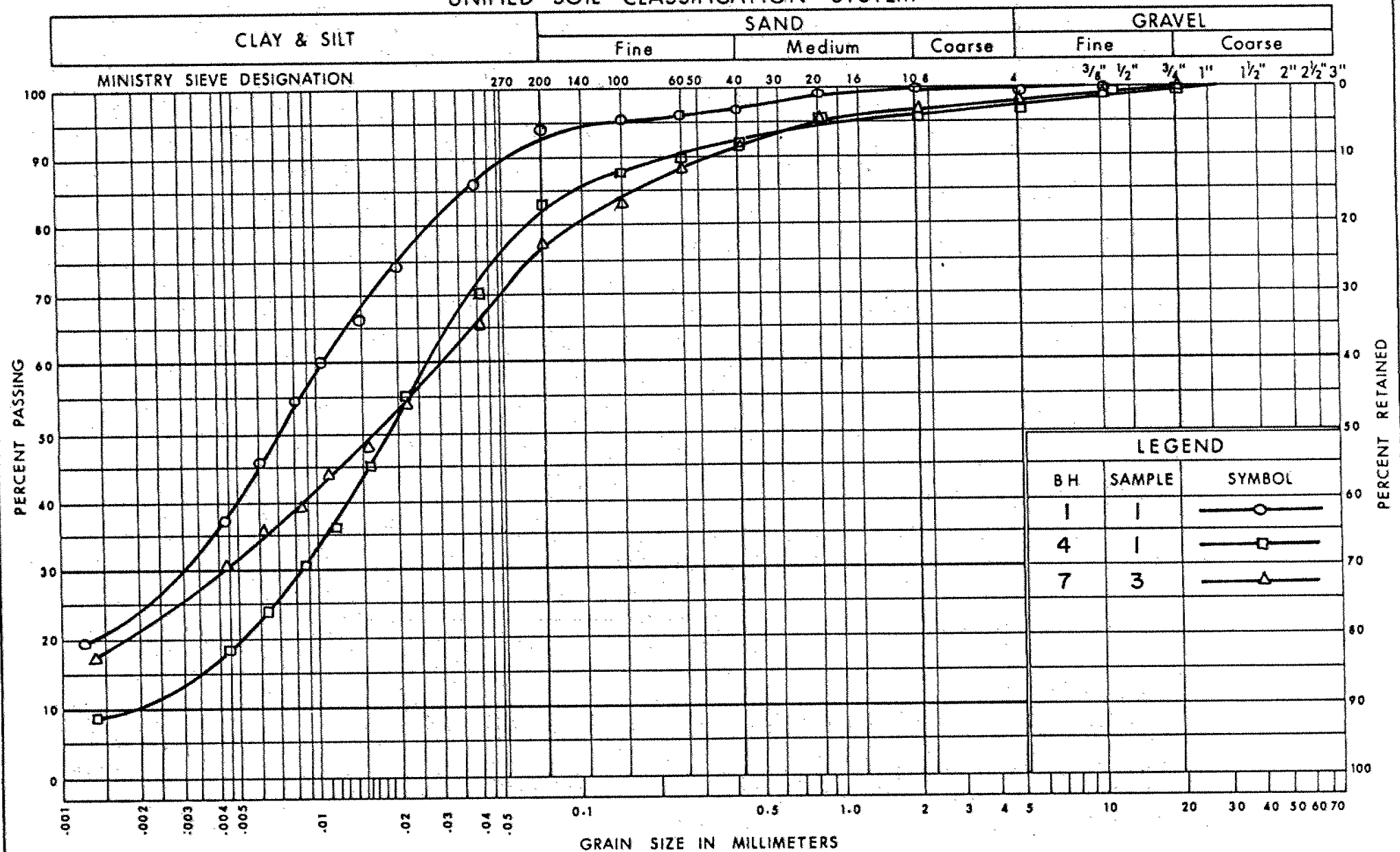
20
15 \div 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 9

W P 837428-A LOCATION Co-ords. 4,799,508N; 278,165E (STA. 9+175) ORIGINATED BY A.H.T.
 DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
 DATUM Geodetic DATE December 30 & 31, 1980 CHECKED BY gh

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
102.44	Ground Level																
0.00	Clayey Silt to Sandy Silt, some gravel (Fill). Stiff.						Seal										
101.37	Dark brown to black, Sandy Silt, some gravel, trace clay (Residual Soil).		1	SS	19		Backfill										
1.07			2	SS	86		101										12 31 53 4
100.15	v. dense. Reddish Brown.						Seal										
2.29	Shale bedrock, slightly weathered reddish brown with grey limestone bands. Short vertical fracture at elev. 99.3 m. Fine grained. Strong.		3	SS	60/76		100										RQD 35%
			4	RC	88%												
99.09			5	RC	98%		99										RQD 50%
3.35	Shale bedrock, faintly weathered. Reddish brown with grey limestone bands about 80 mm thick. Clay seam at elev. 98.4 m. Fine grained. Strong.		6	BXL	98%		Pea Gravel										RQD 70%
96.95							97										W.L. elev. 101.74 on Jan. 5/81
5.49	End of Borehole.						96										

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

Ministry of
Transportation and
Communications

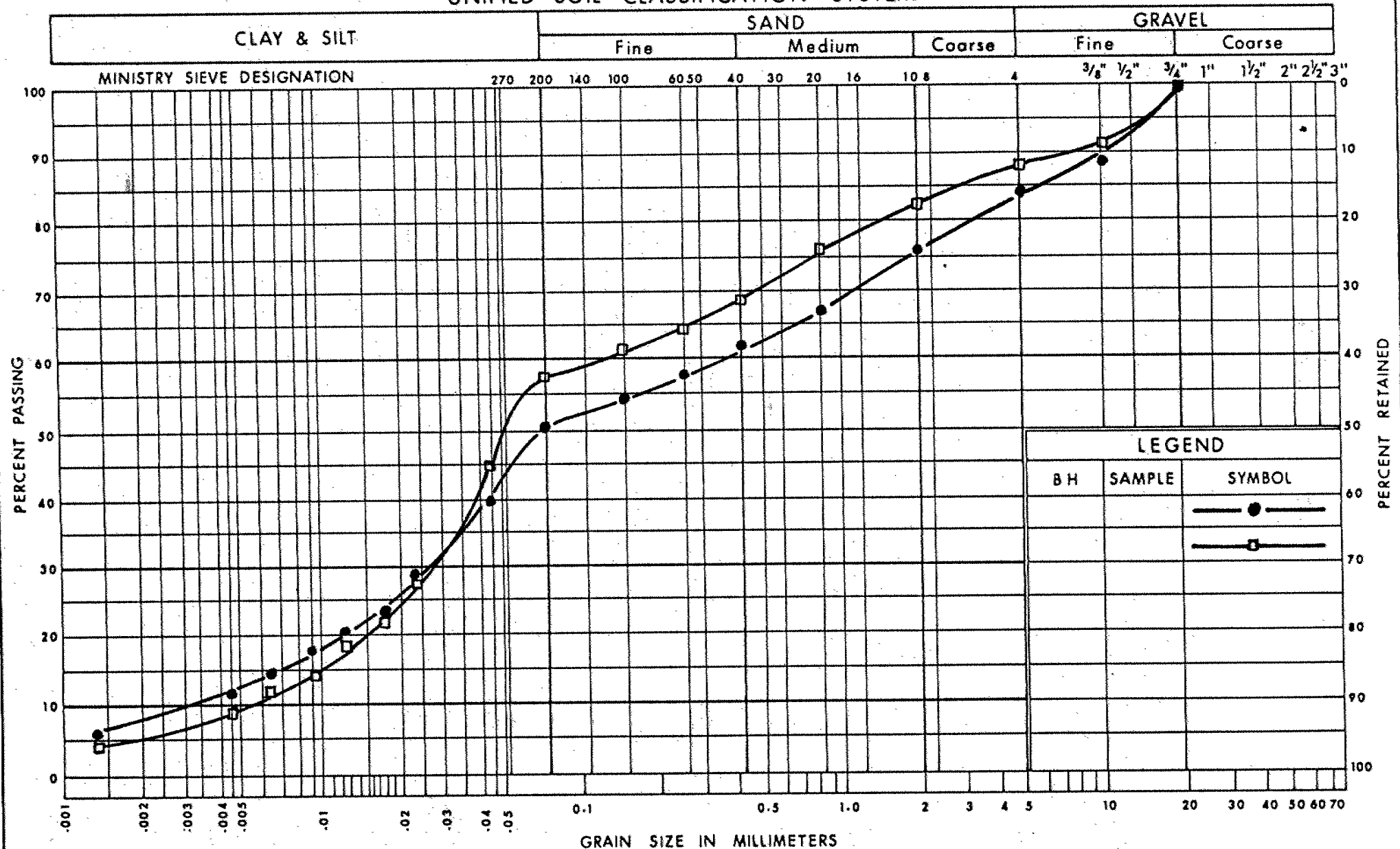
ENGINEERING SERVICES BRANCH

GRAIN SIZE DISTRIBUTION
CLAYEY SILT, TRACE SAND (RESIDUAL SOIL)

FIG No 1

W P 837407

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation and
Communications

Ontario

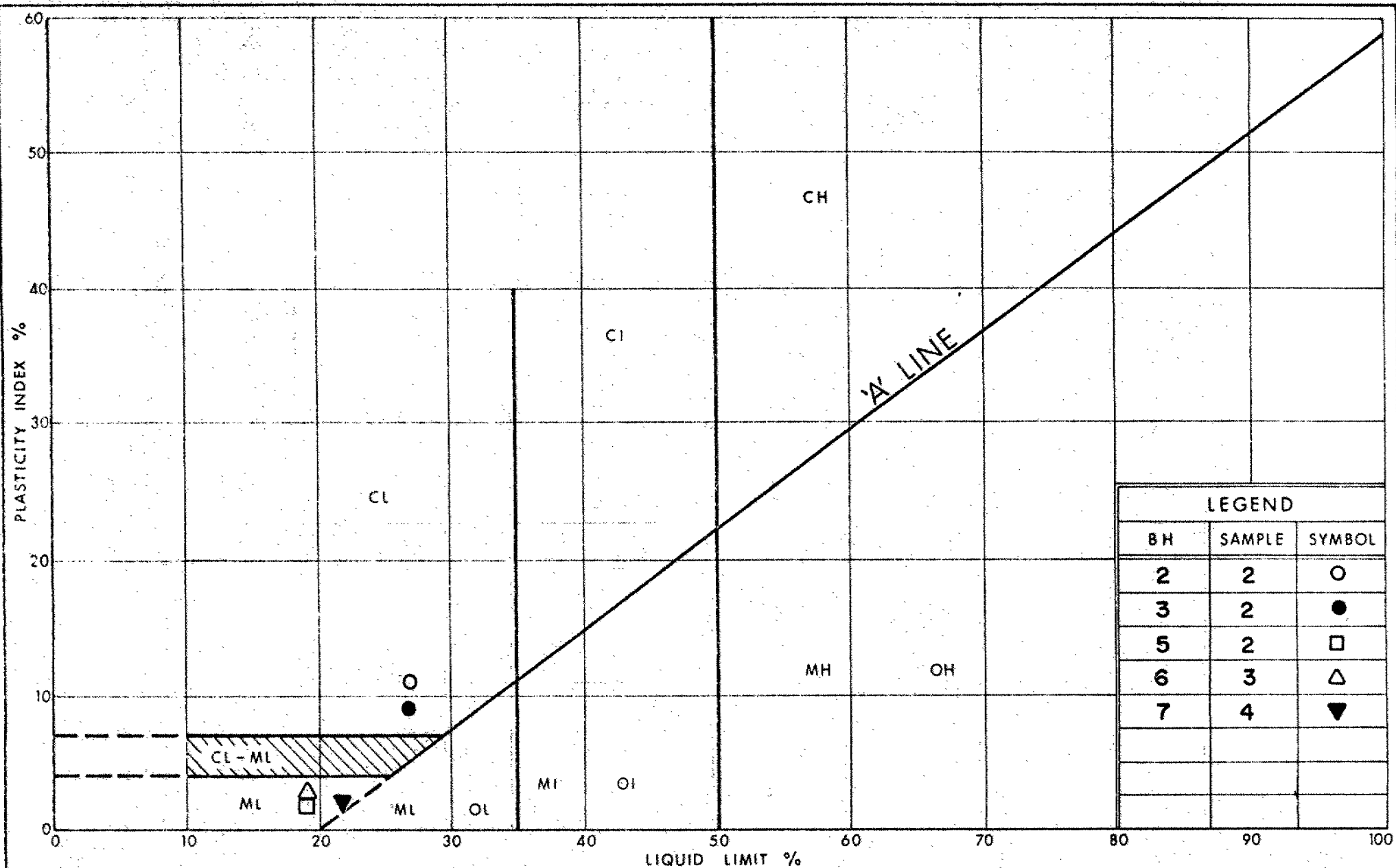
ENGINEERING SERVICES BRANCH

GRAIN SIZE DISTRIBUTION

SANDY SILT (RESIDUAL SOIL)

FIG No 2

W P 837407



Ontario

Ministry of
Transportation and
Communications

PLASTICITY CHART

FIG No 3

W P 837407

OVERSIZE DRAWING

memorandum



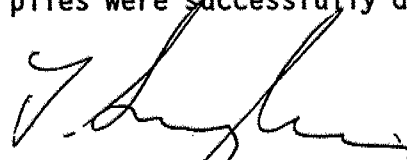
To: Doug McDonald
Project Supervisor, Dist. 4
P.O. Box 5020, Burlington

Date: 1991 10 16

From: Foundation Design Section
Room 315, Central Building

Re: Q.E.W., S.B.L. Ramp S to Hwy. 403 U'Pass
W.P. 83-74-29, Contract No: 91-22

This memorandum hereby summarizes the discussion with Mr. Marr on 91 09 16 regarding the installation of steel H-piles at the north abutment of the above mentioned site. Apparently, one of the piles was driven approximately 0.3 m beyond the proposed tip elevation and did not achieve the recommended pile set criteria (8 blows/25 mm was measured). It is hereby confirmed that the ultimate capacity can still be produced and hence the pile is acceptable as driven, particularly in view of the fact that all other piles were successfully driven.

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

T. Sangiuliano, P. Eng.
Foundation Engineer

for

P. Payer, P. Eng.
Chief Foundation Engineer

PP/TS/jb

memorandum



To: Doug McDonald
Project Supervisor, Dist. 4
P.O. Box 5020, Burlington

Date: 1991 10 16

From: Foundation Design Section
Room 315, Central Building

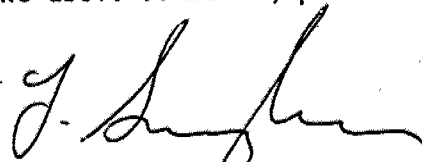
Re: Q.E.W., S.B.L. Ramp S to Hwy. 403 U'Pass
W.P. 83-74-29, Contract No: 91-22

Subsequent to a request issued by the construction field staff supervising the work at the above mentioned site, the undersigned represented the Foundation Design Section in a site inspection to monitor the installation of the steel H-piles proposed at the north abutment and to establish generic pile installation criteria at the site. Installation of the three (3) innermost piles on the south row of the north abutment were monitored. The monitoring consisted of completion of pile driving records and employing the MTO Hiley Dynamic Formula at one of the piles to establish refusal criteria for the remainder of the piles. The two (2) easterly piles inspected were driven to the designed tip elevation and the third pile was driven to elevation 104.7 m or approximately 0.2 m above the designed tip elevation. In all cases, it is suspected with confidence that the piles are bearing on the bedrock and the setting criteria of 20 blows per 25 mm was satisfied. A Berminghammer B400 was used to drive the piles. Based on the observations of the pile installations witnessed, the following procedure is recommended as discussed with your field staff.

- 1) All piles shall be attempted to be driven to bedrock at the designed pile tip elevation as shown on the table given on sheet 154 of the contract documents. The measured penetration of 20 blows per 25 mm shall be confirmed at this tip elevation.
- 2) Any pile tip elevation above the proposed tip elevation can be considered acceptable provided that the 20 blows per 25 mm criteria is satisfied and the pile tip is within a "reasonable" range of the proposed tip elevation (say 0.5 metres).

If the subsurface conditions produce results beyond the limits identified above, please do not hesitate to contact this office. It is, however, suspected that no pile driving impediment is anticipated above the bedrock surface.

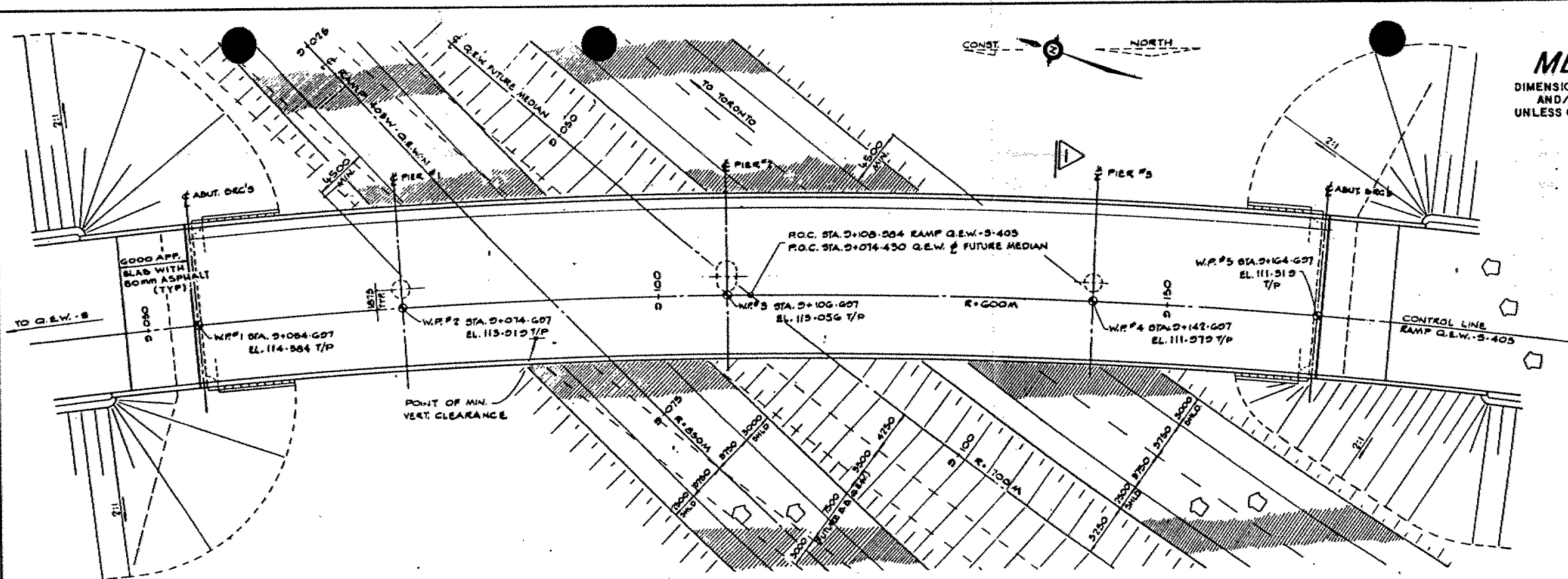
We trust the above assists in facilitating the pile installation at the site. If you have any queries or questions regarding the above comments, please do not hesitate to contact this office.

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

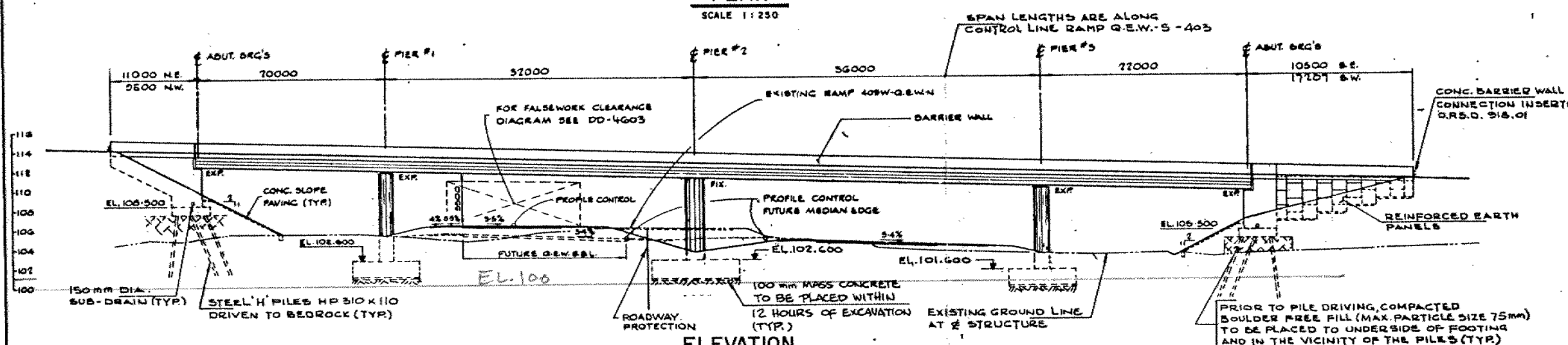
T. Sangiuliano, P. Eng.
Foundation Engineer
for

P. Payer, P. Eng.
Chief Foundation Engineer

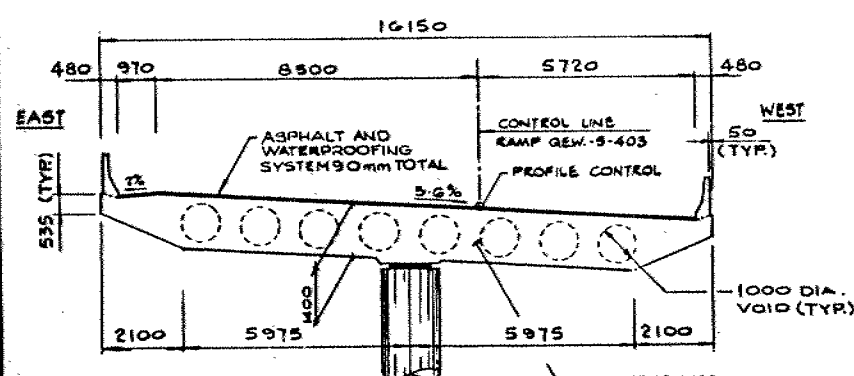
PP/TS/jb



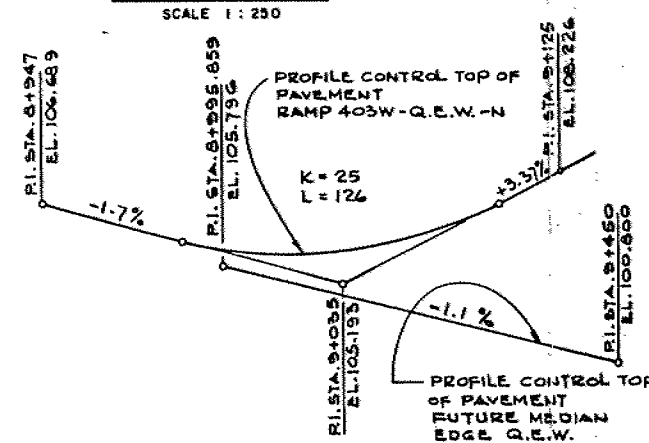
SCALE 1 : 250



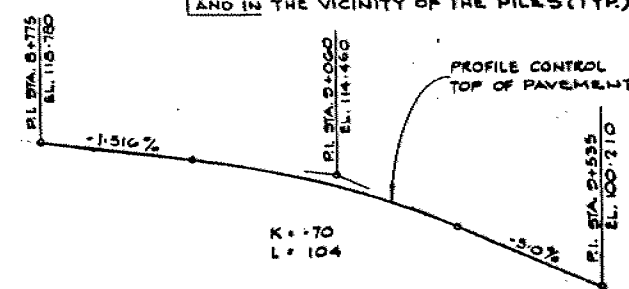
SCALE 1 : 250



SCALE 1:100



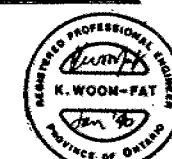
PROFILE OF Q.E.W.
N.T.S.



PROFILE OF RAMP Q.E.W.-S TO HWY. 403

N.T.S.

W.P. — DENOTES WORKING POINTS.
T/P — DENOTES TOP OF PAVEMENT.



DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

DIST. 4
CO No 85-62
WP No 83-74-28



Q.E.W. N.B.L. - RAMP S TO HWY. 403
UNDERPASS
GENERAL ARRANGEMENT

SHEET

McCORMICK RANKIN
CONSULTING ENGINEERS

GENERAL NOTES

CLASS OF CONCRETE

DECK AND PIER COLUMNS	35 MPa
REMAINDER	30 MPa

REINFORCING STEEL

GRADE 408 UNLESS OTHERWISE SPECIFIED.
BAR MARKS WITH SUFFIX 'C' DENOTE COATED BARS.

CLEAR COVER TO REINFORCING STEEL

FOOTINGS 100 ± 25

ABUTMENTS & WINGWALLS:

FRONT FACE	80 ± 20
BACK FACE	70 ± 30
PIER COLUMNS	80 ± 20
DECK: TOP	70 ± 30
BOTTOM AND SIDES	50 ± 10

REMAINDER UNLESS OTHERWISE NOTED----- 79 ± 30

CONSTRUCTION NOTES

IF THE ACTUAL BEARING HEIGHTS ARE DIFFERENT FROM THE ASSUMED HEIGHTS GIVEN WITH THE BEARING DESIGN DATA, THE CONTRACTOR SHALL ADJUST THE BEARING SEAT ELEVATIONS AND THE REINFORCING STEEL TO SUIT THE ACTUAL HEIGHTS.

LIST OF DRAWINGS

1. GENERAL ARRANGEMENT
2. CONSTRUCTION STAGES & ROADWAY PROTECTION
3. BOREHOLE LOCATION & SOIL STRATA
4. FOUNDATION LAYOUT
5. FOUNDATION REINFORCING
6. PIERS & BEARINGS
7. NORTH ABUTMENT
8. SOUTH ABUTMENT
9. REINF. EARTH RETAINING WALL I
10. REINF. EARTH RETAINING WALL II
11. DECK LAYOUT
12. LONGITUDINAL STRESSING
13. TRANSVERSE STRESSING
14. DECK REINFORCING I
15. DECK REINFORCING II
16. EAST BARRIER WALL
17. WEST BARRIER WALL
18. APPROACH SLABS
19. EXPANSION JOINT
20. DETAILS OF CONC. SLOPE PAVING
21. AS CONSTRUCTED ELEV. & DIMENSIONS
22. STANDARDS
23. ELECTRICAL EMBEDDED WORK I
24. ELECTRICAL EMBEDDED WORK II
25. QUANTITIES - STRUCTURE
26. QUANTITIES - STRUCTURE

APPLICABLE STANDARD DRAWINGS.

DD 3503 MINIMUM GRANULAR BACKFILL
REQUIREMENTS.

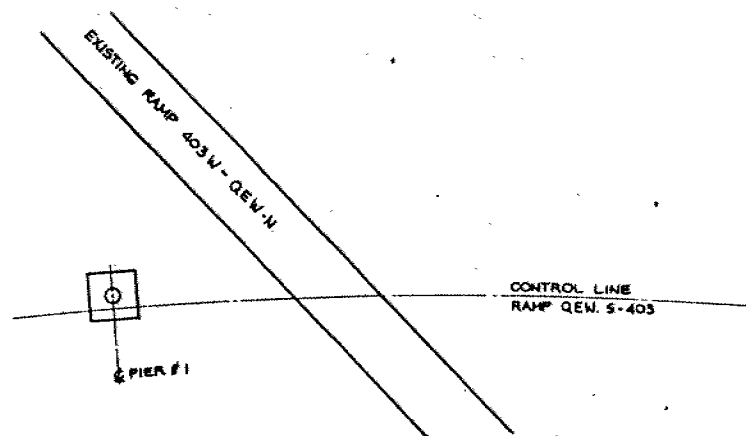
OPSD-918.01 CONNECTION TO NEW STRUCTURES.
DD-4603 FALSEWORK CLEARANCES

REVISIONS					
DATE	BY	DESCRIPTION			
DESIGN J.L.	CHECK R.S.	LOADING	OHBOC-A-83	DATE	APRIL
DRAWING B.L.A.	CHECK K.W.F.	SITE No	10-320	OWG	

DIS CONT WP	No 85-62 No 83-74-28	SHEET
Q.E.W. N.B.L. - RAMP S TO HWY. 403 UNDERPASS CONSTRUCTION STAGES & ROADWAY PROTECTION		
McCORMICK RANKIN CONSULTING ENGINEERS		

METRIC

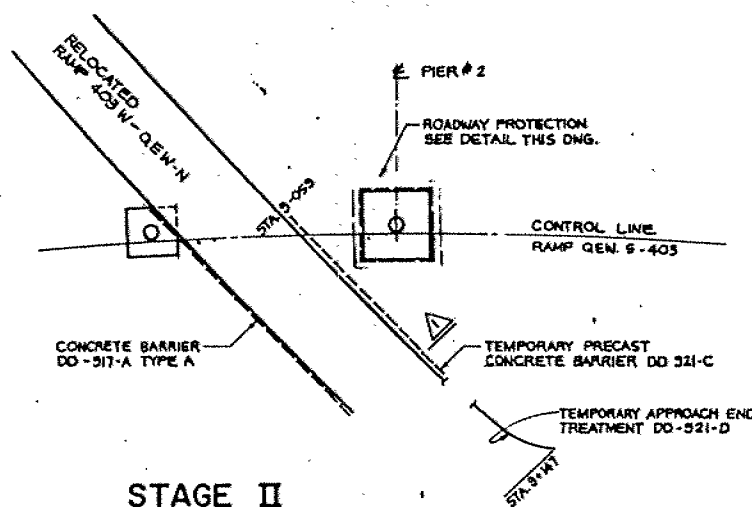
DIMENSIONS ARE IN MILLIMETRES
UNLESS OTHERWISE SHOWN.
ELEVATIONS, COORDINATES, CURVE
AND ALIGNMENT DATA ARE IN METRES.
STATIONS ARE IN KILOMETRES + METRES.



STAGE I

1:500

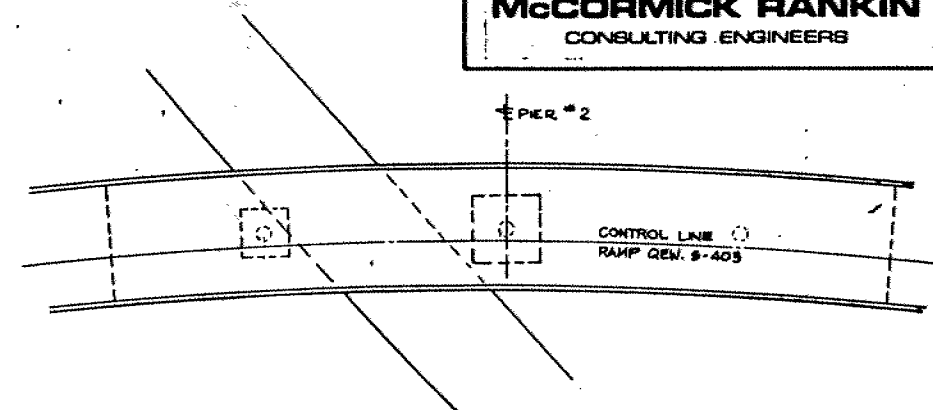
- CONSTRUCT FOOTING AND COLUMN FOR PIER #1



STAGE II

1:500

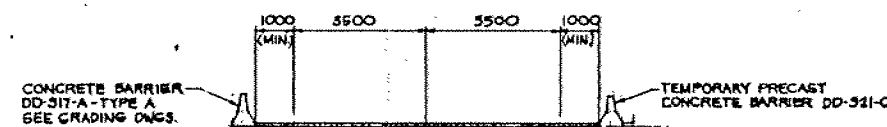
- BACKFILL EXCAVATION FOR PIER #1
- RELOCATE RAMP 403 W - QEW-N
- CONSTRUCT FOOTING AND COLUMN FOR PIER #2 INCLUDING ROADWAY PROTECTION



STAGE III

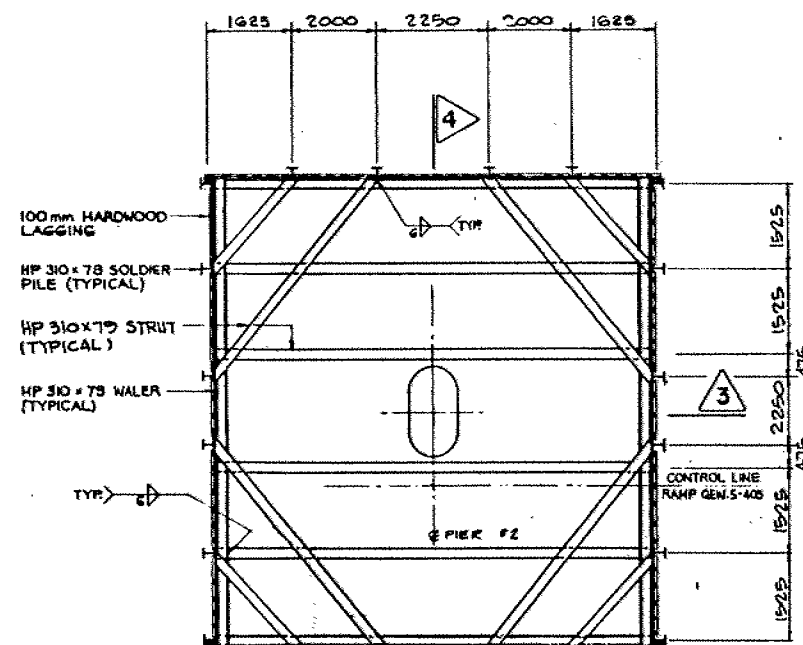
1:500

- COMPLETE THE STRUCTURE



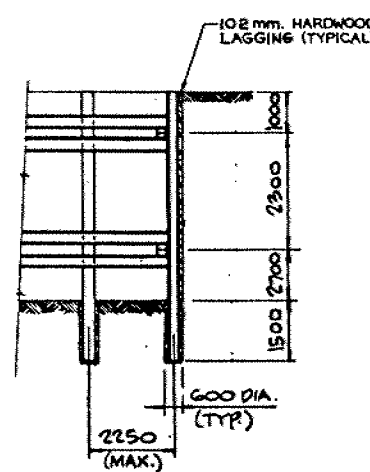
SECTION 1

1:100



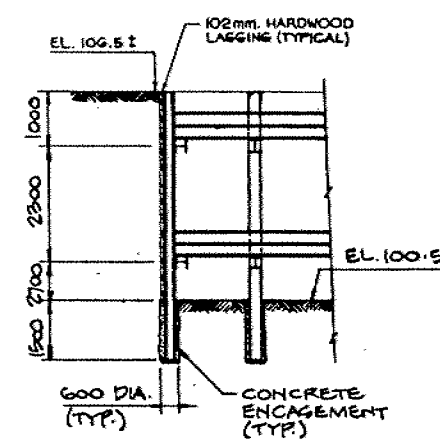
PLAN

N.T.S.



SECTION 3

N.T.S.



SECTION 4

N.T.S.

NOTES:

1. LAGGING TO BE ROUGH - 102mm. HARDWOOD.
2. STRUCTURAL STEEL TO BE SUPPLIED IN ACCORDANCE WITH C.S.A. S40.21 M - 300W.
3. CONCRETE FOR PILE ENCASEMENT - 30 MPa.
4. WELDING OF STRUCTURAL STEEL SHALL CONFORM TO C.S.A. STD. W59-M1984.
5. ALL SHORING TO BE REMOVED TO 1000mm BELOW FINISHED GRADE.

APPLICABLE STANDARD DRAWINGS

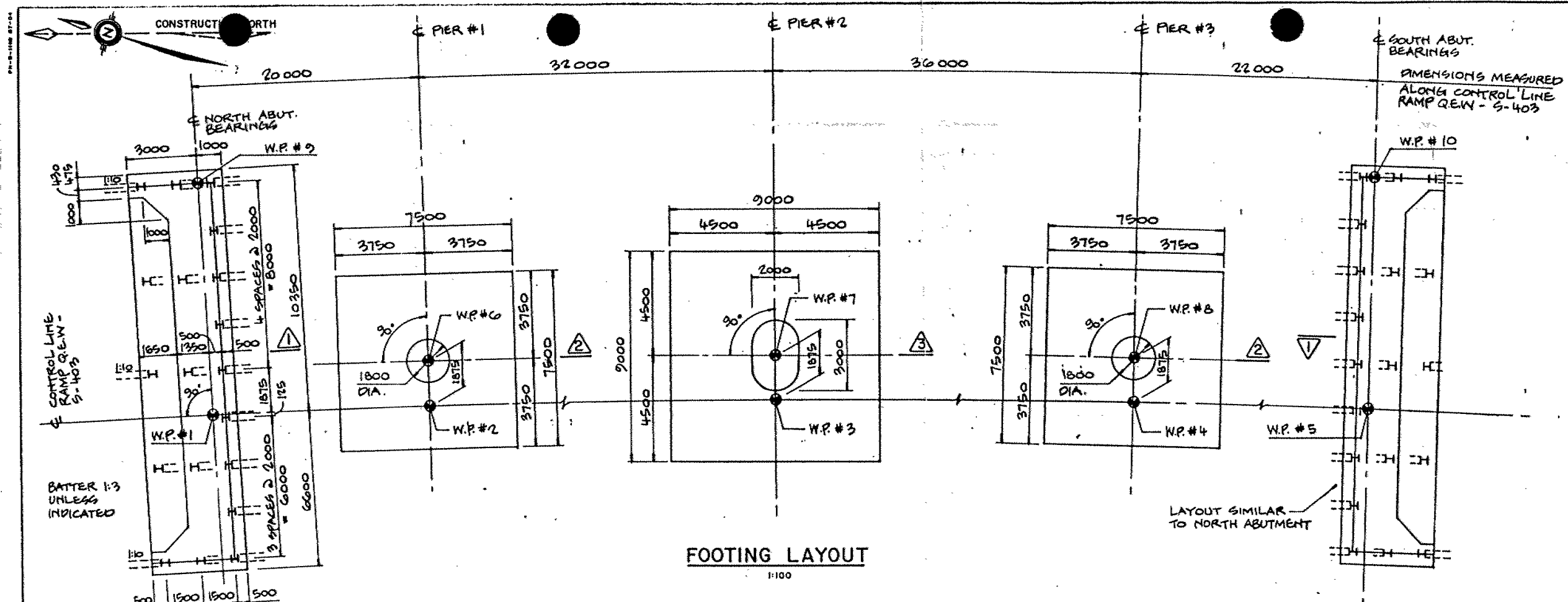
DD-4603 FALSEWORK CLEARANCES



DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	T.W.	CHECK K.W.F.	LOADING CHORD-A-83 DATE APR. 90
DRAWING	R.S.	CHECK K.W.F.	SITE 10-32 DWS 2

SUGGESTED ROADWAY PROTECTION SCHEME

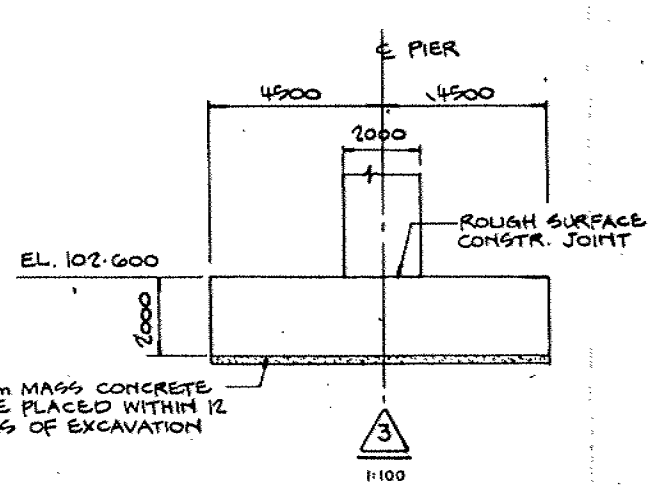
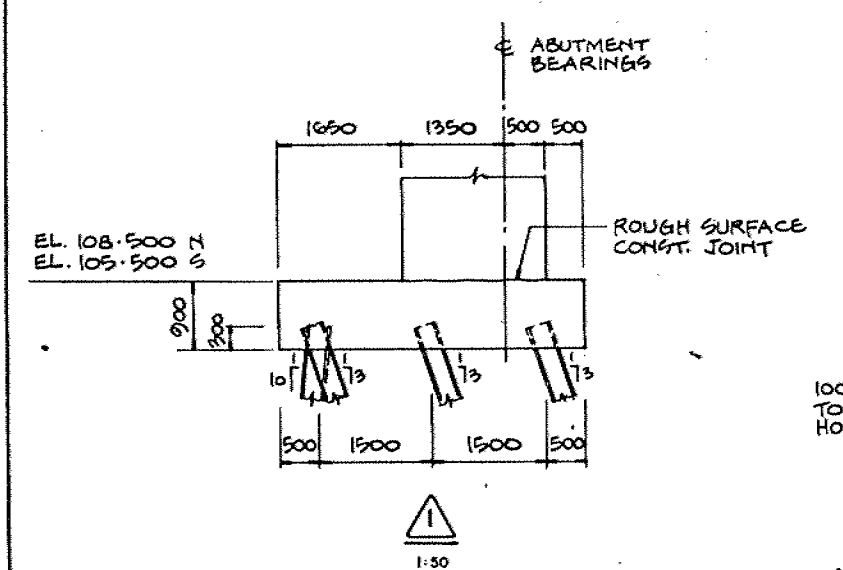


DIS
CONT No 85-62
WP No 83-74-28

Q.E.W. N.B.L. - RAMP S TO HWY. 403 UNDERPASS
FOUNDATION LAYOUT

McCORMICK RANKIN
CONSULTING ENGINEERS

- NOTES**
1. PILES TO BE 310HP X 110 STEEL.
 2. PILE LENGTHS SHOWN ARE THEORETICAL LENGTHS BELOW THE CUT-OFF ELEVATION.
 3. PILE LAYOUT DIMENSIONS ARE TO BE MEASURED AT THE UNDERSIDE OF FOOTINGS.
 4. ALL PILES HAVE DRIVING SHOES

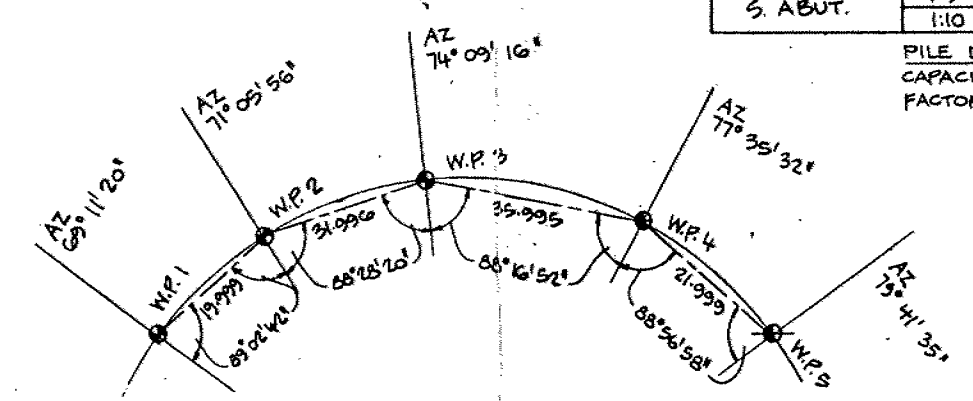
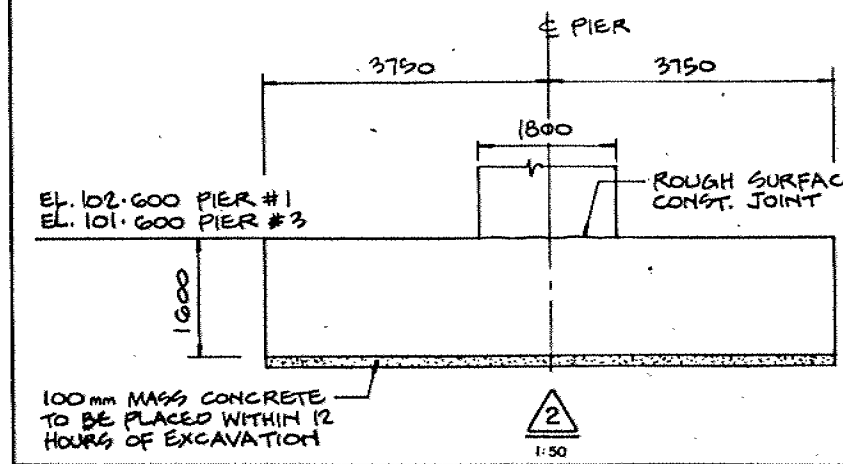


WORK POINT	STATION	CO-ORDINATES	
		NORTH	EAST
#1	9+054.697	4799624.509	278129.564
#2	9+074.697	4799605.698	278136.356
#3	9+106.697	4799575.162	278145.911
#4	9+142.697	4799540.256	278154.696
#5	9+164.697	4799518.688	278159.028
#6	9+074.697	4799606.306	278138.130
#7	9+106.697	4799575.674	278147.714
#8	9+142.697	4799540.699	278156.526
#9	9+054.697	4799628.017	278138.794
#10	9+164.697	4799520.455	278168.743

PILE DATA				
LOCATION	BATTER	QTY	LENGTH	CUT-OFF ELEV.
N. ABUT.	1:3	17	9.4 m	107.900
	1:10	2	8.3 m	107.900
S. ABUT.	1:3	17	6.5 m	104.900
	1:10	2	6.2 m	104.900

PILE DESIGN DATA
CAPACITY AT SLS II — 1150 KN
FACTORED CAPACITY AT ULS — 1600 KN

TIP ELEV.	VERTICAL LENGTH
107.9	8.9
104.9	6.2
98.7	98.7



DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

DATE	BY	DESCRIPTION
APR 90	CHK KWF	CODE OHBDC-A-83/LOAD CLASS A/DATE
	DRAWN A.M.	CHK KWF/SITE 10-320/STRUCT SCHEME DWG. 4

memorandum



To: G. Al-Bazi
Design Engineer
7th Floor, Atrium Tower

From: Foundation Design Section
Room 315, Central Building

Re: Q.E.W. NBL - Ramp S to Hwy. 403 Underpass
W.P. 83-74-28, Site 10-320
Hwy. 403, District 4, Burlington

Date: 1990 10 16

The final drawing No's 1, 2, and 4 for the above noted project were reviewed and the following comments are submitted.

- 1) It appears that the piles for the north and south abutments will have to be driven through 1.8 m to 4.0 m of shale bedrock.
- 2) Based on the bedrock condition, the actual pile length may be expected to vary substantially from the pile lengths indicated in the drawing No: 4.
- 3) The working concrete pad for pier foundations should be placed within 6 hours of exposure.


P. Payer, P. Eng.
Sr. Foundation Engineer

for

M. Devata, P. Eng.
Chief Foundation Engineer

MD/PP/jb

**McCORMICK, RANKIN & ASSOCIATES
LIMITED**

consulting engineers

October 19, 1981

Mr. Ken Selby, P. Eng.
Senior Foundation Engineer
Pavement & Foundation
Design Section
Room 313
Central Building
1201 Wilson Avenue
DOWNSVIEW, Ontario
M3M 1J8

RE: QEW South - Hwy. 403
Ramp Over
QEW N.B.L. & S.B.L.
Sites 10-320 & 10-321
W.P. 83-74-28 & 29
District 4, Hamilton
Our File: W.O. 1183-100 & 200



Dear Sir:

This letter will confirm our telephone conversation dated October 9th with you regarding foundation application of O.H.B.D.C. for the above mentioned projects.

W.P. 83-74-28 & 29

1) Spread Footings on Weathered Shale

(El. 103.3 to 101.1 for site 10-320)
(El. 104.7 to 103.8 for site 10-321)

Factored Capacity at U.L.S.	600 KPa
Capacity at S.L.S. type II	400 KPa
Friction coefficient between soil and base	tan 10.35°

2) Spread Footings in Granular Fill at Abutments

Factored Capacity at U.L.S.	600 KPa
Capacity at S.L.S. type II	350 KPa
Friction coefficient between soil and base	0.50

3) Piles Driven to Bedrock - 310 HP @ 110 Steel Piles

Factored Capacity at U.L.S.	1600 KN
Capacity at S.L.S. type II	1150 KN

.....

-2-

Mr. Ken Selby, P. Eng.

All H - piles shall be equipped with reinforced tips.
In addition, soil properties should be computed as per subsection
6.6.1.2.2 of the O.H.B.D.C.

If you have any questions, regarding this criteria,
please call.

Yours very truly,

McCORMICK, RANKIN & ASSOCIATES LIMITED

John Lam P. Eng

John Lam, P. Eng.

JL:rs

cc: Mr. W. Lin, P. Eng.

SEND
TO

G. AL-BAZI

STRUCTURAL OFFICE

7TH FLOOR, ABRIUM TOWER

FROM

P. PAYER

FOUNDATION DESIGN

DATE

90 04 30

SUBJECT

WP. 83-74-28

RECOMMENDED FOOTING LEVELS

PILES: $4\phi 310 \times 110$; U.L.S: 1600 kN; S.L.S. TYPE II: 1150 kN
 PILE TIP LEVELS: NORTH ABUT. EL. 103.0; SOUTH ABUT. EL. 102.0
 ALTERNATIVE: ABUTMENTS ON COMPACTED GRANULAR 'A' CORRE;
 U.L.S: 900 kPa; S.L.S. TYPE II: 340 kPa.

PIERS: THE BASE OF THE FOOTINGS SHOULD NOT BE HIGHER
 THAN: EL. 103 (PIER #1), EL. 102.5 (PIER #2) AND EL. 101.2 (PIER #3)
 BUT THE FROST PENETRATION DISTANCE OF NOT LESS THAN
 1.2 m SHOULD BE KEPT.

P. Payer

REPLY

REPLY FROM

REPLY DATE

COPY

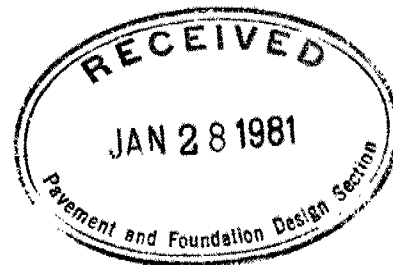


Golder Associates

CONSULTING GEOTECHNICAL AND MINING ENGINEERS

January 16, 1981

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



ATTENTION: Mr. K. Selby, P. Eng.
Senior Foundation Engineer

RE: FOUNDATION INVESTIGATION
PROPOSED BRIDGE
QEW/403 INTERCHANGE
W.P. 83-74-28; Site 10-320

Dear Sirs:

This letter reports the preliminary findings and recommendations of a subsurface investigation which was carried out by Golder Associates for the Ministry of Transportation and Communications, at the site of a proposed overpass bridge on the QEW/403 Interchange in Burlington, Ontario.

Details of the project were provided on a plan titled "Bridge Site, Proposed Northbound QEW Underpass at Ramp QEW-S to Hwy. 403" designated Site 10-320, dated September 30, 1980. This structure has been numbered W.P. 83-74-28 and forms part of an overall project under W.P. 83-74-07. It is understood that the proposed bridge will be a four span post-tensional type with spans of approximately 22 m, 45 m, 39 m and 22 m. It will allow for QEW northbound traffic to proceed westerly along Hwy. 403. The centre column is to be located at the median of the future QEW.

The following is a summary of the subsurface conditions encountered at Site 10-320 where 5 boreholes (BH 5 to 9 inclusive) were put down:

A layer of topsoil varying in thickness up to 0.3 m was encountered except at the location of the existing Hwy. 403 exit ramp to the QEW and at the southern end of the site near the existing QEW eastbound lanes. Near the exit ramp a borehole (BH 7) encountered 1.4 m of crushed stone (sand and gravel sizes). The topsoil and granular fill is underlain by clayey silt containing pieces of brick and thin lenses of black organic material, and is considered to be local fill. The fill varies in thickness from 0.6 m at the northern end of the site to 2.0 m at the exit ramp. The fill is underlain by hard clayey silt containing a trace of sand and gravel to sandy silt containing some gravel, with red shale fragments throughout. This stratum is considered to be residual soil rather than a glacial till due to the coarser fraction of the material being quite angular and friable. It extends to depths between 2.3 m and 4.4 m below ground surface.

The water content of the sandy silt is about 10 per cent and that of the clayey silt is about 17 per cent. Both materials (forming the residual soil) exhibit low plasticities with liquid limits between 16 to 22 per cent and a plasticity index of about 2. The residual soil is underlain by between 1.0 m and 2.0 m of highly weathered reddish brown weak shale and then followed by faintly weathered stronger shale. The shale is irregularly banded with limestone layers about 80 mm in thickness and an occasional thin red clay seam.

Based on the above findings the following alternative foundation designs are recommended at Site 10-320:

The bridge structures may be founded on shallow spread footings placed in the hard natural residual soil or weathered shale bedrock. An allowable bearing pressure of 320 kPa may be used for the design of footings placed approximately at a depth of 2 m into the natural soil, that is, between elevation 102.3 at the north end of the site to elevation 99.4 at the south end of the site. The footings may also be carried to competent shale bedrock which should be encountered about 2 m below the surface of the shale, that is, between elevation 101.2 and 98.1 m at the north end and south end of the site, respectively. An allowable bearing pressure of 640 kPa may be used for design of footings placed in the more competent shale.

All footings should be placed a minimum 1.2 m below final exterior grade for frost protection. To allow construction of footings placed below the groundwater level suitable shoring of the excavations will be required. The control of groundwater inflow by methods such as pumping from sumps will also be required. The base of all footing excavations should be inspected by a qualified geotechnical engineer prior to placement of any concrete.

Consideration should be given to the effect of high (up to 11 m) approach embankment loads on the settlement of bridge abutments. The embankment loads are apt to induce settlement of the underlying soils which in turn drags down the abutments. Since the bridge piers are not subjected to the same loading, the settlements are largely differential. In this case, although significant settlements are not anticipated, it would be prudent to extend the abutment footings to competent rock.

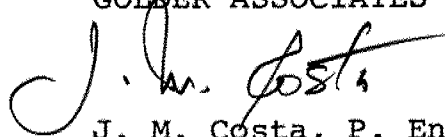
As an alternative to abutments on spread footings, consideration could be given to adopting perched abutments founded on piles driven through the embankment and end-

bearing on the competent shale bedrock which underlies the site between elevation 101.2 and 98.1 m. Steel H-piles, such as 12BP53 pile section driven to a set of 20 blows/25 mm using a driving energy of at least 54 kilo joules per blow may be designed using an allowable load of as much as 667.5 kN per pile.

We trust that these preliminary recommendations are sufficient for your immediate requirements. Should you have any questions concerning this letter, please contact us.

Yours truly,

GOLDER ASSOCIATES



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Q.E.W. South - Hwy. 403 W Ramp Over Q.E.W. N.B.L.
Site No. 10-320, W.P. 83-74-28
District 4, Hamilton

The foundation investigation program for the above mentioned project has now been completed by Golder Associates, geotechnical consulting engineers. Attached, please find their letter summarizing the subsurface conditions encountered across the site and the design recommendations pertaining to the structure foundations and related earthworks. The complete foundation investigation report and drawing for this site will be forwarded to you upon its receipt and review by this Section.

Additional comments with regards to the foundation recommendations are as follows:

- 1) Spread footings should be carried up from competent shale bedrock using mass concrete to effectively raise the founding elevation to an economic level.
- 2) For excavations carried down to shale bedrock, provisions should be made to pour a minimum 0.15 m thick slab of lean concrete over the base of the excavation immediately after excavation operations to prevent weathering of the exposed shale surface.
- 3) Steel 'H' section piles driven to bedrock should be equipped with reinforced flange plates at the pile tip to facilitate driving through the weathered shale.
- 4) On page 4 of the consultant's letter, the sentence should read "Steel H-piles, such as 310 HP 79 pile section driven to a set of 20 blows/25 mm using a driving energy of at least 54 kJ per blow may be designed using an allowable load of as much as 670 kN per pile."
- 5) In order to resist lateral forces acting on the abutment wall foundations, frictional forces between the footing and the underlying residual soil can be calculated using a coefficient of friction of 0.6. The lateral earth pressure exerted on the abutment wall by the granular backfill can be computed assuming a unit weight of 20.5 kN/m³ for the backfill and a coefficient of earth pressure ' K_0 ' of 0.5. Backfilling operations and

drainage measures should be carried out as per current M.T.C. standards.

- 6) Minimal settlement/stability problems are anticipated for the approach embankment fills and slopes provided they are constructed to a 2:1 geometry.

We trust the information provided is sufficient in scope for your immediate requirements. Should further discussion be warranted, please feel free to contact this Section.

TK:ea

T. Kazmierowski
Project Foundations Engineer

Attach.

cc: R. Fitzgibbon

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 30M5-123
30M5-124

DIST. 4 REGION

W.P. No. 83-74-29

CONT. No. 91-22

W. O. No.

STR. SITE No. 10-321

HWY. No. 403

LOCATION South of Q.E.W / Hwy 403
W Ramp

No of PAGES -

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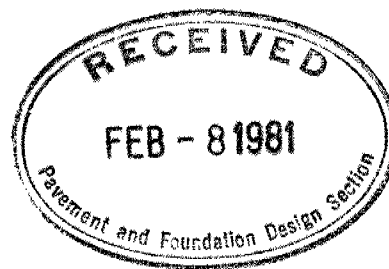
OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:



Golder Associates

CONSULTING GEOTECHNICAL AND MINING ENGINEERS



REPORT
TO

MINISTRY OF TRANSPORTATION
AND COMMUNICATIONS

FOUNDATION INVESTIGATION
PROPOSED OVERPASS BRIDGES AT Q.E.W./
HWY. 403

W.P. 93-74-28

DISTRICT 4

W.P. 93-74-29 CONT 91-22

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January, 1981

801-1341

3045-123
GEOLOGES " " = 124

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ABSTRACT

A subsurface investigation was carried out by Golder Associates for the Ministry of Transportation and Communications at the site of two proposed overpass bridges on the QEW/403 Interchange in Burlington, Ontario.

In summary, the borings indicate that stiff to hard clayey silt fill overlies a hard clayey to sandy silt (residual soil) stratum which overlies Queenston shale bedrock at depths between 1.5 and 2.3 m below existing ground surface. The shale bedrock is highly weathered for the top two metres. Groundwater levels measured during the investigation were at or just above the fill/residual soil contact and generally follow the surface topography.

The proposed structures may be founded in the natural soil or in competent bedrock. Perched abutments placed within the embankment fill may be adopted. Depending on the tolerance of the proposed structures to differential settlement these abutments may be placed directly on specially prepared fill or founded on piles driven through the embankment and bearing on bedrock.

1.0 INTRODUCTION

Golder Associates have been retained by the Ministry of Transportation and Communications (letter dated December 5, 1980) to carry out a foundation investigation for two proposed overpass bridges on the QEW/403 Interchange in Burlington, Ontario (overall W.P. 837407).

The purpose of the investigation was to determine the subsurface conditions at the site and based on these data, to provide engineering recommendations for the geotechnical design of the foundations for the proposed structures.

The investigation was carried out, and this report was prepared, in accordance with Golder Associates' letter, dated December 23, 1980.

2.0 DESCRIPTION OF PROJECT

Details of the project were provided during a meeting between Mr. Selby of the Ministry of Transportation and Communications, and Messrs. Davis and Busbridge of Golder Associates on December 15, 1980. Additional details were provided on two plans titled "Bridge Site, Proposed Northbound QEW Underpass at Ramp QEW-S to Hwy. 403" designated Site 10-320, W.P. 837428-A, dated September 30, 1980, and "Bridge Site, Proposed Southbound QEW Underpass at Ramp QEW-S to Hwy. 403" designated Site 10-321, W.P. 837429-A, dated October 1, 1980, and in an M.T.C. memorandum dated October 27, 1980. It is understood that the above mentioned projects form part of overall W.P. 837407.

It is understood that at Site 10-320, the proposed bridge will be a four span post-tensioned type with spans of approximately 22 m, 45 m, 39 m and 22 m. It will allow for QEW northbound traffic to proceed westerly along Hwy. 403. The centre column is to be located at the median of the future QEW.

At Site 10-321 it is understood that the proposed bridge will be a three span post-tensioned type with spans of approximately 20 m, 40 m and 20 m. It will allow for traffic carried by the previous bridge deck to overpass the future QEW southbound lanes and proceed westerly along Hwy. 403.

The approximate locations of the footings were shown in red on the two plans provided, along with profiles of both QEW and the ramps under consideration in this area.

3.0 SITE AND GEOLOGY

The proposed bridges are to be located along the QEW, south of the North Service Road and west of Brant Street in the City of Burlington, Ontario. The topography at the site is generally flat lying having an elevation about 106 m (Geodetic). Immediately to the north of the site the land rises towards the Niagara Escarpment.

The site is located in the physiographic region known as the Iroquois Plain, consisting of a narrow strip of land along the shores of the present Lake Ontario. This level plain was formed by post-glacial Lake Iroquois which then occupied the Lake Ontario basin. In the Burlington area the surficial soils in this plain consist of beach sands, clayey silt till and/or residual red clayey silt derived from weathering of the underlying Queenston shale bedrock. The Queenston shale formation consists of thinly bedded red clay shale with occasional bands of grey limestone.

4.0 INVESTIGATION PROCEDURE

The field work for this investigation was carried out between December 22 and 31, 1980. The elevations of the boreholes were determined on January 5, 1981. During this time nine boreholes were put down at the two sites (Drawings 837428-A and 837429-A) using a Type 5.3.i drillrig supplied and operated by Master Soil Investigations Ltd., of Toronto, a specialist drilling contractor. Within the overburden soils the boreholes were advanced with solid stem augers. In each

boring, standard penetration tests were carried out at 0.76 m intervals of depth, and samples were obtained using a standard 50 mm O.D. split spoon sampler, which was advanced by a 63.5 kg mass falling freely for 0.76 m. In each boring, bedrock was cored for depths of between 2.8 m to 3.8 m in BXL size. Details of the drilling and sampling operations are summarized on the Record of Borehole sheets. A filtered standpipe was sealed into each boring to allow monitoring of the groundwater level.

The field work was supervised throughout by a member of Golder Associates' engineering staff, who located the borings in the field, cleared underground services, directed the drilling and sampling operations, logged the borings and cared for the samples. The borehole locations were established by tape measurement. The ground surface elevations at each boring was determined relative to an M.T.C. survey monument (Drawing 837428-A). The elevation of this control point was provided by a member from the M.T.C. staff on January 8, 1981. It is understood that all ground surface elevations are referred to Geodetic datum.

Following field identification and logging, all the samples obtained during the investigation were placed in air-tight containers and brought to our laboratory where they were examined in detail. Representative samples of the soil were tested to determine their index properties.

5.0 SUBSURFACE CONDITIONS

The detailed stratigraphy encountered in each of the boreholes together with the results of laboratory tests carried out on representative samples of the soil strata are given on the attached Record of Borehole sheets and on Figures 1 to 3. The locations of the boreholes and the simplified stratigraphy at the boreholes are shown on Drawings 837428-A and 837429-A. It should be noted that the stratigraphic boundaries indicated on the borehole logs and longitudinal sections are inferred from a transition from one soil type

to another and do not necessarily indicate an exact plane of geologic change. Further, the subsurface conditions may vary between boreholes.

5.1 Site 10-320

At the locations of Boreholes 5, 6 and 8, up to 0.3 m of topsoil was encountered at ground surface. A layer of granular material comprising crushed stone (sand and gravel sizes) was encountered at Borehole 7 and extends to a depth of 1.4 m (Elev. 104.8 m). This material forms part of the shoulder of the existing Highway 403 exit ramp to the QEW. The topsoil at Boreholes 5, 6 and 8, the granular fill at Borehole 7 as well as ground surface at Borehole 9 are underlain by a layer of clayey silt containing some sand and gravel, pieces of red brick and occasional thin lenses of black organic matter. This fill varies in thickness from 0.6 m at Boreholes 5 to 2.0 m at Borehole 7. The fill is underlain by hard (N^* values greater than 30) clayey silt containing a trace of sand and gravel to sandy silt containing some gravel, with red shale fragments throughout.

The clayey silt material has a grain size distribution (Figures 1 and 2) similar to that of a glacial till. However, the coarser fraction of the soil is angular and easily friable. This material has the characteristics of a residual soil (soil material with the original texture, structure and mineralogy of the rock completely destroyed) rather than the matrix of a glacial till. It extends to a depth of about 2.3 m (between Elev. 100.1 m to 103.2 m) below ground surface except at Borehole 7 where it extends to 4.4 m (Elev. 101.8 m) below ground surface. The fill has a grain size distribution similar to that of the residual soil (Figure 1 - BH7, SA 3) and is probably local material placed during previous construction activities.

The water content of the sandy silt is about 10 per cent and that of the clayey silt is about 17 per cent. Both

*N - Standard Penetration Resistance - See Explanation of Terms, Appendix A.

materials (forming the residual soil) exhibit low plasticities with liquid limits between 16 to 22 per cent and a plasticity index of about 2 (Figure 3). The residual soil encountered at Boreholes 5 and 9 is more granular (Figure 2) than that of Boreholes 6, 7 and 8, possibly due to it containing more weathered shale fragments. This material is underlain by highly weathered to faintly weathered, reddish brown, weak to strong Queenston shale. The shale is irregularly banded with grey limestone layers about 80 mm in thickness and an occasional thin seam of red clay. The core recovery was generally in excess of 70 per cent and the Rock Quality Designations (RQD) lies between zero and 80 per cent, the higher quality being recorded for core recovered about 2 m below the overburden/bedrock interface.

As is evidenced from the profile shown on Drawing 837428-A ground surface and the various stratigraphic units slope gently from north (BH 5) to south (BH 9). The top surface of the residual soil also slopes towards the south but is more erratic due to the surface having been changed by previous construction activities and fill placement. The elevation of Borehole 7 is higher than the other boreholes in the same general area due to it being located near the southern shoulder of the exit ramp from Hwy. 403.

The groundwater surface measured in the standpipes also slopes towards the south generally following the ground surface topography.

5.2 Site 10-321

At the location of Boreholes 1 to 4 the ground surface is underlain by between 0.12 and 0.36 m of topsoil. At Boreholes 3 and 4, the topsoil overlies a layer of fill composed of clayey silt containing some sand and gravel, pieces of red brick and occasional thin lenses of black organic matter. The fill extends to a depth of 1.1 and 0.5 m (Elev. 104.9 and 105.1 m) below ground surface at the location of these two boreholes. The topsoil at Boreholes 1 and 2 and the fill at

Boreholes 3 and 4 is underlain by between 0.7 and 1.6 m of stiff to hard (N values 17 to 39) reddish brown clayey silt containing a trace of sand and gravel and numerous red shale fragments, and is considered to be residual soil. The residual soil was penetrated to about 1.5 to 1.8 m (Elev. 103.8 to 104.7 m) below ground surface at which depths refusal to augering was encountered. The higher 'N' values given on the Record of Borehole sheets and on the profile shown on Drawing 837429-A were obtained at the overburden/bedrock contact.

The water content of the residual soil lies between 11 and 16 per cent which is below the plastic limit of the material and indicative of a heavily overconsolidated soil. The material exhibits low plasticity with a plasticity index of about 10 (Figure 3).

Bedrock was extracted by BXL rock coring techniques. The bedrock was found to be a highly weathered to faintly weathered at depth, reddish brown, weak to strong at depth, Queenston shale. The shale is irregularly banded with grey limestone layers about 80 mm in thickness and is occasionally intercepted by thin seams of red clay. The core recovery was about 73 per cent and the RQD was between zero and 60 per cent and generally below 50 per cent. This indicates that the shale bedrock is of generally poor to fair quality.

The groundwater level measured within the standpipes slopes towards the south, generally following the surface topography. Although the water level is indicated as being higher at Borehole 3 than at Borehole 2 this may be due to an interceptor ditch located near Borehole 2 thereby depressing the water level in this area.

6.0 DISCUSSION AND RECOMMENDATIONS

The recommendations for the geotechnical aspects of design of the proposed structures, together with the comments on the construction aspects of the work contained

in this section of the report are for the guidance of the design engineer only. Contractors bidding on or undertaking the works should make their own interpretation of the factual information provided as it affects their proposed construction methods, equipment selection, scheduling and the like.

6.1 Bridge Foundations

The natural soils and rock found at the site are suitable for the support of approach embankments and bridge foundations. Depending on the most economical proportioning of footing dimensions and excavation requirements, together with the tolerance of the proposed structure to differential settlement, various options may be considered.

6.1.1 Bearing Pressure - Site 10-320

At Site 10-320 the bridge may be founded on shallow spread footings placed in the hard natural residual soil and/or weathered shale. An allowable bearing pressure of 320 kPa may be used for the design of footings placed at least 2 m into the natural residual soil and/or weathered shale bedrock which underlie the site between elevation 102.3 m (BH 5) and 99.4 m (BH9).

As an alternative to founding the proposed structure in the residual soil and/or weathered shale, consideration should be given to carrying the footings to competent shale bedrock which should be encountered about 2 m below the surface of the shale, that is, at approximately between elevations 101.6 m (BH 6) and elevation 99.1 m (BH 9). An allowable bearing pressure of 640 kPa may be used for design of footings placed in the more competent shale.

6.1.2 Bearing Pressures - Site 10-321

The bridge structure at this site may be founded on shallow spread footings founded at least 2 m into the hard natural residual soil and/or weathered shale which underlies

the site. An allowable bearing pressure of 320 kPa may be used for the design of footings placed at least 2 m into the natural residual soil and/or weathered shale bedrock.

As an alternative to founding the proposed structure in the residual soil and/or weathered shale, the footings may be founded on competent shale bedrock which should generally be encountered at about elevation 103 m. An allowable bearing pressure of 640 kPa may be used for design of footings placed in competent shale. It should be stressed that at the location of BH 1 the highly weathered shale bedrock extends down to at least elevation 101.7 m and was not penetrated. Footings extending to competent shale bedrock will have to be founded at a lower elevation in this area.

6.2 Special Considerations for Abutments

Consideration should be given to the effect of high (up to 10 m) approach embankment on the settlement of bridge abutments. The embankment loads are apt to induce settlement of the underlying soils which in turn drags down the abutments. Since the bridge piers are not subjected to the same loading, the settlements are largely differential.

6.2.1 Abutments on Spread Footings

Where abutments are placed on the residual soil or highly weathered shale bedrock it is anticipated that a differential settlement of up to 50 mm could develop between the abutment and the adjacent bridge pier. This can be reduced to less than 25 mm by ensuring that footings are taken down to the competent shale as discussed in 6.1.1 and 6.1.2.

Where the abutments are required to act as retaining walls the lateral earth loads will depend on the type and method of placement of the fill materials. The following recommendations are made in respect to the design of the

abutment retaining walls:

- (i) Selected granular fill, such as M.T.C. Granular 'B' should be used as backfill immediately behind the structures. The granular fill should be placed in the wedge-shaped zone defined by a 45 degree line extending up and back from the rear face of the structures' footings;
- (ii) All granular fill should be compacted in 200 mm thick lifts to 95 per cent of the standard Proctor dry density of the material. However, heavy compaction equipment should not be used behind any structure within a lateral distance equal to the current height of the fill above the base of the structure;
- (iii) Provided that the above criteria are satisfied, a coefficient of active earth pressure (K_a) of 0.3 may be used in computing lateral earth pressures, if an outward deflection of approximately 1/2 per cent of the wall height can be tolerated at the bridge bearings. If this amount of deflection cannot be absorbed, than an at-rest coefficient of earth pressure (K_o) equal to 0.5, should be used in calculating the lateral earth pressures. A coefficient of friction less than or equal to 0.55 may be assumed between the concrete footings and the bedrock. A bulk unit weight of 20 kN/m^3 may be assumed for the Granular 'B' backfill;
- (iv) An adequate drainage system should be provided behind the abutments to prevent build-up of hydrostatic forces. The drainage system should include a properly designed filter to prevent clogging of the pipes. Provision should be made to allow cleaning or rodding of the pipes, should they become clogged.

6.2.2 Perched Abutments

As an alternative to abutments on spread footings consideration could be given to adopting perched abutments placed within the embankment fill. Depending on the degree of continuity of the bridge deck structure and therefore its tolerance to differential settlement these abutments can be supported on specially prepared embankment material or on piles driven through the embankment fill.

Where no piling is used it will be necessary to remove all existing fill and to replace with granular fill, compacted to a minimum of 100 per cent of the Standard Proctor density. The granular material should extend from the underside of the abutment down to the natural soil at a slope of 2 horizontal to 1 vertical. Material within 1.5 m of the underside of the abutment should conform to M.T.C Granular 'B' specification. An allowable bearing pressure of 200 kPa may be used for the design of the abutment footing provided it is placed a minimum of 3 m from the face of the slope measured at the founding level. Where the bridge structure cannot tolerate a differential settlement of 75 mm between abutment and pier it is recommended that perched abutments are founded on piles driven through the embankment fill.

The piles should be founded on the shale bedrock. Steel H-pile section HP310 x 79 driven to a set of 20 blows/25 mm using a driving energy of at least 54 kilo joules per blow will be capable of supporting a working load of 700 kN per pile.

6.3 General Considerations

All footings should be placed a minimum 1.2 m below final exterior grade for frost protection.

To ensure that the footings are placed on relatively undisturbed natural residual soil, weathered shale or

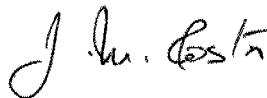
competent bedrock, it is recommended that the base of all footing excavations be inspected by a qualified geotechnical engineer prior to placement of any concrete.

6.4 Comments on Construction

It is anticipated that it will be possible to excavate the top 4 m of shale by ripping although progress may be slow where bands of limestone are encountered. The ingress of water into the excavations must be prevented as water will soften the shale. Further, the foundations should not be exposed any more than necessary and should not be left open overnight. A coating of working concrete should be applied to the foundation surface as soon as possible after excavation.

In order to allow construction of footings placed below the groundwater level, suitable shoring of the excavations will be required. The control of groundwater inflow by methods such as pumping from sumps will also be required.

GOLDER ASSOCIATES



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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/0.3m)	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 (R Q D), FOR MODIFIED RECOVERY, IS:

R Q D (%)	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

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

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 = $\frac{c_u}{\tau_r}$

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

W P 837429-A LOCATION Co-ords 4.799.746N: 278.076 E (STA B+ 921) ORIGINATED BY A.H.T.
 DIST 4 HWY OEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
 DATUM Geodetic DATE December 22, 1980 CHECKED BY J.S.C.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH								WATER CONTENT (%)	
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL							x LAB VANE
106.24	Ground Level														GR SA SI CL		
0.00	Topsoil						Seal 106										
0.36	Clayey Silt with shale fragments (Residual soil). Hard.		1	SS	39		Backfill								0 6 70 24		
104.72	Red and Greenish Grey.		2	SS	50/127 mm		105										
1.52	Shale Bedrock. Highly weathered reddish brown, fine grained, weak, irregularly banded with grey limestone layers about 80mm thick. 76mm clay seam at Elev. 103.3 m.		3	R.C. BXL	95%		104								RQD 31%		
101.70			4	RC BXL	89%		103								RQD 9%		
4.54	End of Borehole.						102										
							101								W.L. elev 105.17 on Jan.5, 1981		

+3, x5: Numbers refer to
Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No.2

W P 837429-A LOCATION Co-ords 4,799,727 N; 278,084 E (STA B+942.5) ORIGINATED BY A.H.T.
 DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
 DATUM Geodetic DATE December 23, 1980 CHECKED BY J. Smith

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
106.33	Ground Level																
0.00	Topsoil						Seal 106										
0.24	Clayey Silt, some shale fragments (residual soil).						Backfill										
			1	SS	17												
	Very Stiff.																
104.50	Reddish Brown.																
1.83	Shale bedrock, highly weathered, reddish brown, fine grained, weak.		2	SS	25												
	32mm clay seam at Elev. 103.7 m.																
103.28			3	RC BXL	91%												RQD 18%
3.05	Shale Bedrock.																
	Faintly weathered reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		4	RC BXL	100%												RQD 30%
							Pea Gravel										
101.21			5	RC BXL	100%												RQD 42%
5.12	End of Borehole.																W.L. elev. 104.44 on Jan. 5/81

+3, x5: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No. 3

W P 837429-A LOCATION Co-ords 4,799,692 N; 278,102 E (STA B+982.5) ORIGINATED BY A.H.T.
DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
DATUM Geodetic DATE December 23, 1980 CHECKED BY J.H.C.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
105.96	Ground Level																GR SA SI CL
0.00	Topsoil						Seal										
0.12	Clayey silt (Fill).						Backfill										
104.89	Hard. Brown to Black.		1	SS	17		105										
1.07	Clayey silt, with shale fragments (Residual Soil).																
104.19	Hard. Reddish brown.		2	SS	115/279		104										
1.77	Shale Bedrock. Highly weathered. Reddish brown, fine grained, weak.		3	RC BXL	73%												-RQD 0%
103.16	Shale Bedrock.						103										RQD 0%
2.80	Faintly weathered, reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		4	RC BXL	92%		Pea Gravel										RQD 60%
101.33			5	RC BXL	100%		102										
4.63	End of Borehole.						101										W.L. elev. 104.53 on Jan. 5/81

RECORD OF BOREHOLE No.4

W P 837429-A LOCATION Co-ords 4,789,673 N; 278,111 E (STA 9+002.5) ORIGINATED BY A.H.T.
 DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
 DATUM Geodetic DATE December 23 & 24, 1980 CHECKED BY J.L.F.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
105.56	Ground Level																
0.00	Topsoil						Seal										
0.12	Clayey Silt (Fill).						105										
105.10	Stiff, Brown.																
0.46	Clayey Silt, some gravel and shale fragments (Residual Soil).		1	SS	23		Backfill										3 13 73 11
103.79	Hard, Reddish Brown.		2	SS	84		104										
1.77	Shale Bedrock.			Rc													RQD 53%
103.33	Moderately Weathered,																
2.23	Shale Bedrock. Faintly weathered, reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		3	BXL	98%		103										
			4	Rc			Pea Gravel										
				BXL	97%		102										RQD 33%
100.96							101										Standpipe frozen at ground level on Jan. 5/81
4.60	End of Borehole.						100										

RECORD OF BOREHOLE No. 5

W P 837428-A LOCATION Co-ords. 4,799,633 N; 278,130 E (STA 9+047) ORIGINATED BY A.H.T.
DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
DATUM Geodetic DATE December 29, 1980 CHECKED BY J.W.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT $\frac{Z}{\text{mm}}$					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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
105.42	Ground Level																
0.00	Topsoil						Seal										
105.12	Clayey to Sandy Silt (Fill).		1	SS	15		105										
104.65	Stiff Red to Dark Brown																
0.91	Sandy silt, some gravel, trace clay (Residual Soil).		2	SS	28		Backfill										
							104										
			3	SS	76												16 34 42 8
103.27	Dense. Reddish Brown.						103										RQD 0%
2.29	Shale Bedrock. Slightly Weathered. Reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		4	SS	65/100 mm		102										RQD 48%
			5	RC BXL	11%												
			6	RC BXL	97%		101										RQD 73%
101.29	Shale Bedrock. Faintly weathered reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.						Pea Gravel										
4.27			7	RC BXL	101%		100										
99.68	End of Borehole.						99										W.L. Elev. 104.87 on Jan. 5/81

+3, x5: Numbers refer to
Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No.6

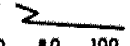
W P 837428-A LOCATION Co-ords. 4,799,610N; 278,139E (STA. 9+071) ORIGINATED BY A.H.T.
DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
DATUM Geodetic DATE December 29, 1980 CHECKED BY J.C.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100								WATER CONTENT (%) 10 20 30
								SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE								
105.47	Ground Level															
0.0	Topsoil															
0.15	Clayey to Sandy Silt, some gravel (Fill).		1	SS	17		Seal	105								
			2	SS	18											
103.67	Compact, Brown.		3	SS	38		Backfill	104								
1.80	Clayey Silt, some gravel (Residual Soil).															
103.13	Hard, Reddish Brown.		4	SS	70/1		Seal	103								
2.34	Shale Bedrock. Moderately weathered reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		5	RC BXL	98%			102						RQD 23%		
101.63																
3.84	Shale Bedrock, Faintly weathered reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		6	RC BXL	100%		Pea Gravel	101						RQD 57%		
99.80								100								
5.67	End of Borehole.							99						W.L. elev. 103.85 on Jan. 5/81		



RECORD OF BOREHOLE No.7

W P 837428-A LOCATION Co-ords. 4,799,575N; 278,151E (STA. 9+108) ORIGINATED BY A.H.T.
DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
DATUM Geodetic DATE December 30, 1980 CHECKED BY J.H.C.

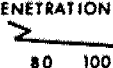
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	N° VALUES			20 40 60 80 100										
								SHEAR STRENGTH					WATER CONTENT (%)					
								○ UNCONFINED	+	FIELD VANE				10	20	30		
								● QUICK TRIAXIAL	x	LAB VANE								
106.22	Ground Level																	
0.0	Crushed Stone (Sand and Gravel sizes) (Fill).						Seal 106											
104.85	Very Dense, Brown.		1	SS	59		105											
1.37	Clayey Silt, some sand, trace gravel (Fill).		2	SS	44		Backfill 104											
	Stiff to Hard.		3	SS	13		103										2 20 57 21	
102.84	Brown.		4	SS	40		102											
3.38	Clayey Silt, some sand, trace gravel and shale fragments (Residual Soil).		5	SS	60/162		Seal 102											
101.80	Hard. Reddish Brown.		6	SS	60/162		101											
4.42	Shale Bedrock. Highly weathered. Reddish brown. Fine grained. Weak.		7	RC	39%		100										RQD 0%	
100.73	Shale Bedrock. Moderately weathered reddish brown, fine grained, strong. Irregular banded with grey limestone layers about 80 mm thick.		8	RC	120%		99										RQD 53%	
5.49	Shale Bedrock. Faintly weathered. Reddish brown with irregular grey limestone bands.		9	RC	78%		98										RQD 41%	
99.15	Fine grained. Strong.		10	BXL	86%												RQD 86%	
7.07	End of Borehole.																W.L. elev. 102.44 on Jan. 5/81	
98.08																		
8.14																		

+3, x5: Numbers refer to
Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No.8

W P 837428-A LOCATION Co-ords. 4,799,531N; 278,161E (STA. 9+152) ORIGINATED BY A.H.T.
 DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
 DATUM Geodetic DATE December 29 & 30, 1980 CHECKED BY J.L.C.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
103.01	Ground Level																
0.00																	
102.70	Topsoil																
0.31	Sandy Silt to Clayey Silt (Fill). Very Stiff. Brown.																
102.06																	
0.95	Sandy Silt to Clayey Silt with gravel (Residual Soil). Hard. Reddish Brown.		1	SS	35		102										
101.18			2	SS	65/152		101										
1.83	Shale Bedrock. Highly weathered. Reddish brown with irregular grey limestone bands about 80 mm thick. Fine grained. Weak,		3	RC BXL	44%		100										RQD 0%
99.11			4	RC BXL	100%		99										RQD 34%
3.90	Shale Bedrock. Slightly weathered. Reddish brown with irregular grey lime- stone bands about 80 mm thick. 75 mm clay seam at Elev. 99.1 m. Fine grained. Strong.		5	RC BXL	99%		98										RQD 45%
97.68			6	RC BXL	100%		97										RQD 100%
5.33	End of Borehole.		7	RC BXL	100%												RQD 100%
																	W.L. elev. 102.13 on Jan. 5/81

+3, x⁵: Numbers refer to
Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

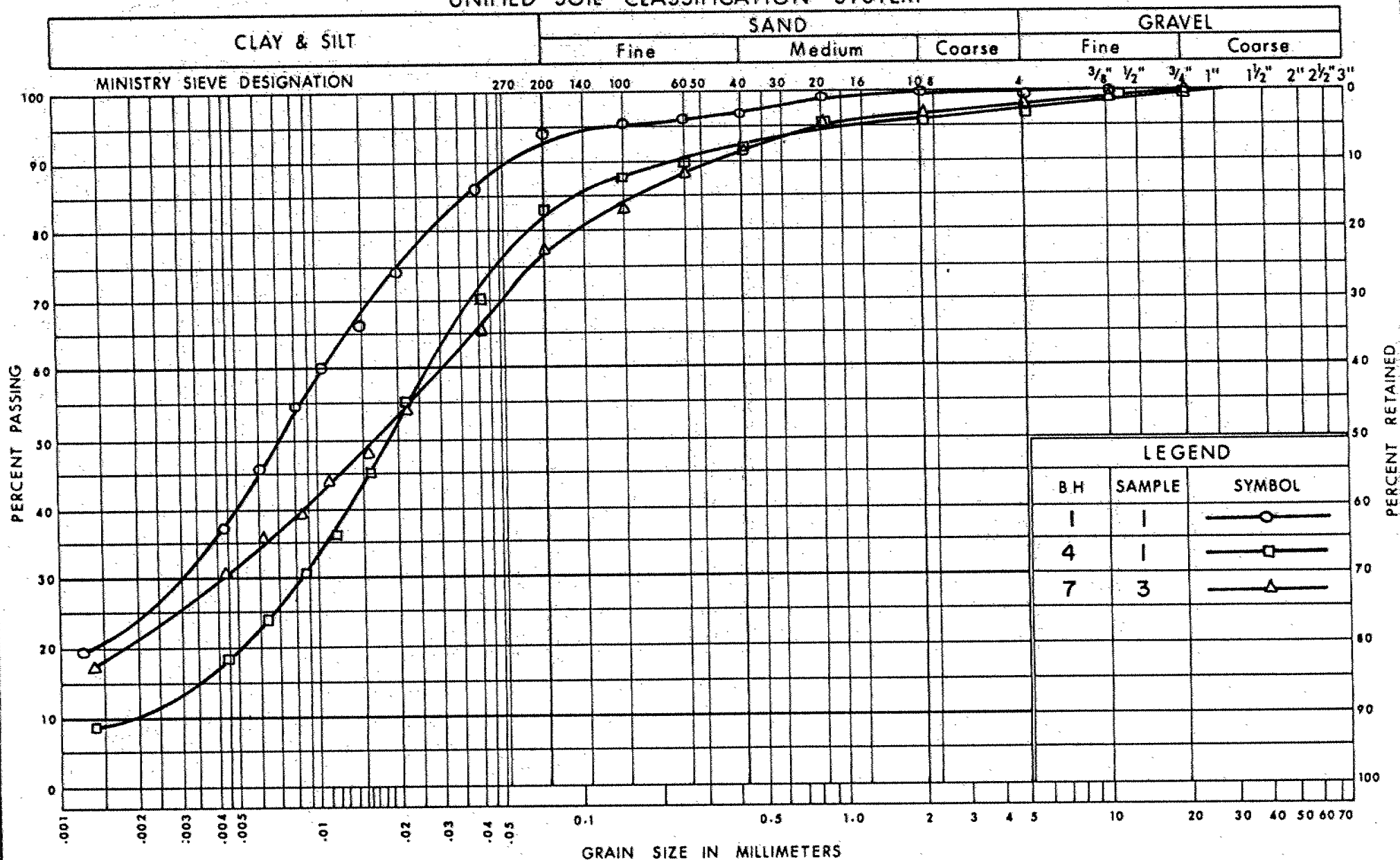
OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 9

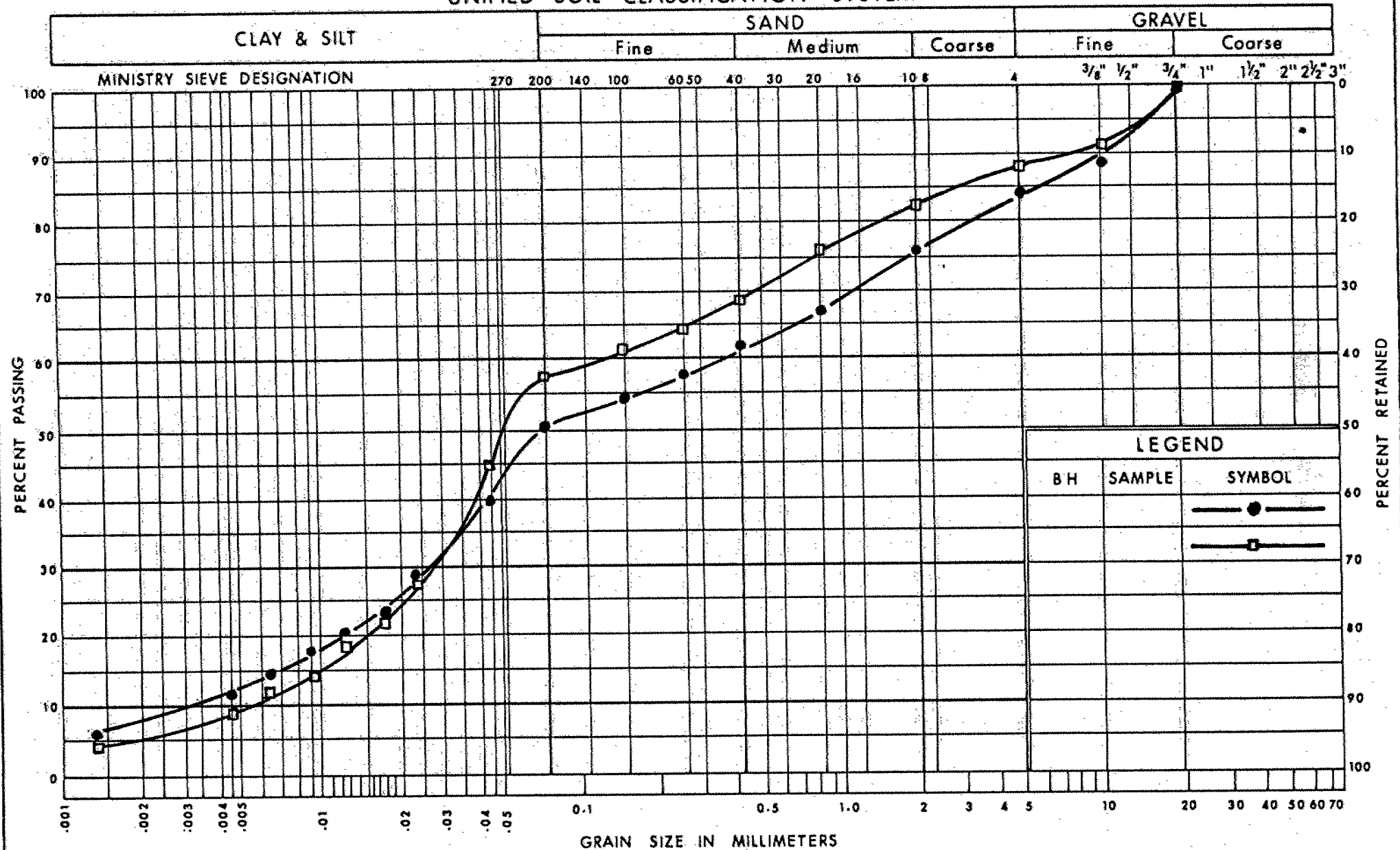
W P 837428-A LOCATION Co-ords. 4,799,508N; 278,165E (STA. 9+175) ORIGINATED BY A.H.T.
 DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
 DATUM Geodetic DATE December 30 & 31, 1980 CHECKED BY J.H.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	N' VALUES			20	40	60	80	100		
102.44	Ground Level													
0.00	Clayey Silt to Sandy Silt, some gravel (Fill). Stiff.					Seal	102							
101.37	Dark brown to black, Sandy Silt, some gravel, trace clay (Residual Soil).		1	SS	19	Backfill	101							12 31 53 4
100.15	v. dense. Reddish Brown.		2	SS	86									
2.29	Shale bedrock, slightly weathered reddish brown with grey limestone bands. Short vertical fracture at elev. 99.3 m.		3	SS	60/76	Seal	100							RQD 35%
99.09	Fine grained. Strong.		4	RC BXL	88%									RQD 50%
3.35	Shale bedrock, faintly weathered. Reddish brown with grey limestone bands about 80 mm thick. Clay seam at elev. 98.4 m. Fine grained. Strong.		5	RC BXL	98%		99							
96.95			6	RC BXL	98%	Pea Gravel	98							RQD 70%
5.49	End of Borehole.						97							W.L. elev. 101.74 on Jan. 5/81
							96							

UNIFIED SOIL CLASSIFICATION SYSTEM



UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation and
Communications

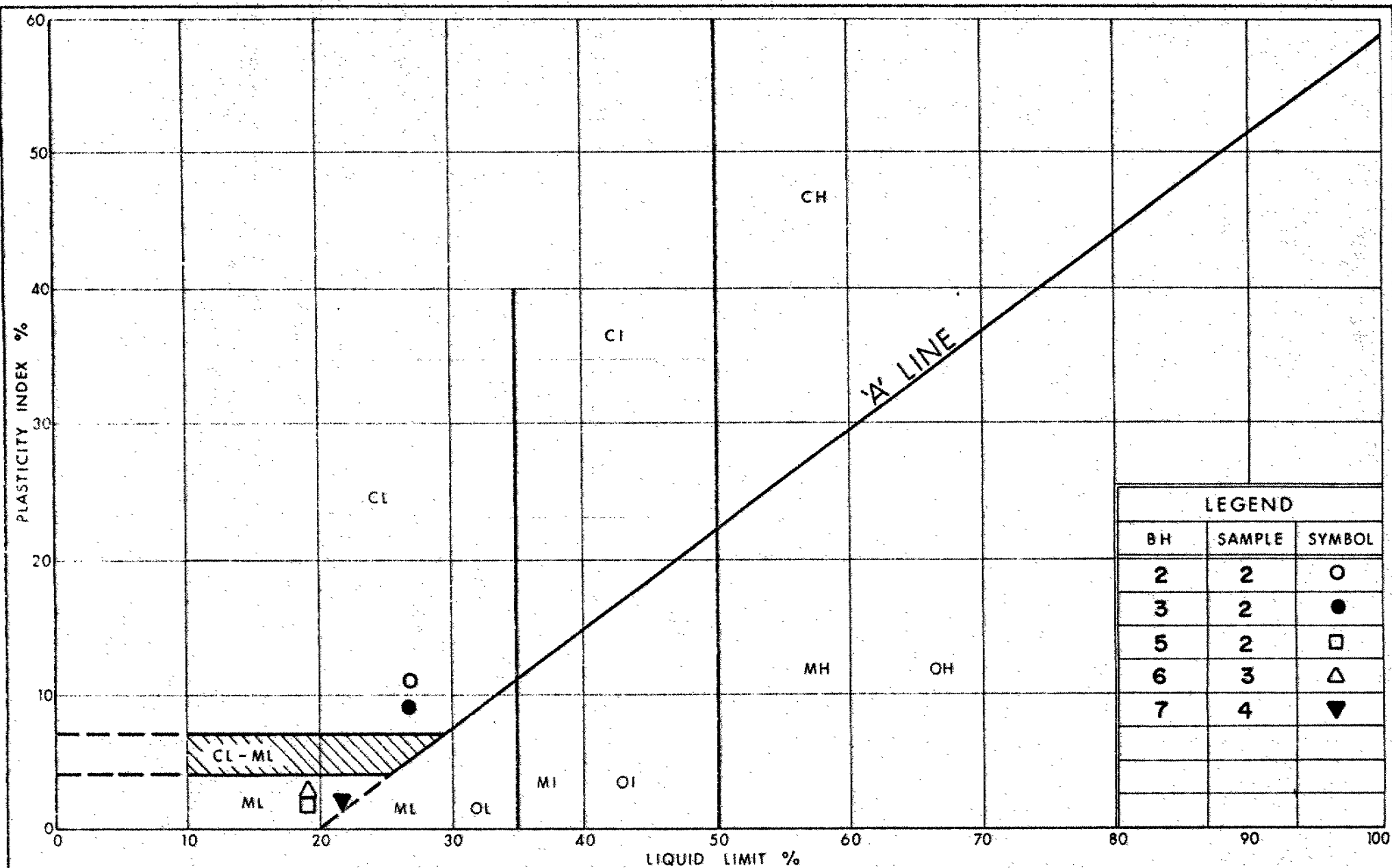
Ontario

ENGINEERING SERVICES BRANCH

GRAIN SIZE DISTRIBUTION SANDY SILT (RESIDUAL SOIL)

FIG No 2

W P 837407



LEGEND		
BH	SAMPLE	SYMBOL
2	2	○
3	2	●
5	2	□
6	3	△
7	4	▼



Ministry of
Transportation and
Communications

PLASTICITY CHART

FIG No 3

W P 837407 CT

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

Pavement & Foundation Design Section
Room 313, Central Building

81 02 18

Q.E.W. South - Hwy. 403 Ramp Over
Q.E.W. N.B.L. & S.B.L.
Sites 10-320 & 10-321
W.P. 83-74-28 & 29
District 4, Hamilton

The firm of Golder Associates, geotechnical consulting engineers, have completed the foundation investigation program for the above mentioned projects. Please find attached the final report and drawings for these sites which have been reviewed by this Section.

Our comments regarding recommendations pertaining to the structure foundations and related earthworks are as follows.

Pier foundations may be founded on spread footings located on the weathered shale interface. For design estimating purposes, footings found at elevations ranging from 103.3 to 101.1 for Site 10-320 and from elevation 104.7 to 103.8 for Site 10-321 can be designed for an allowable bearing pressure of 400 kPa. Mass concrete may be used to effectively raise the founding elevation of the spread footings from the weathered shale surface to an economic level.

Perched abutments in the approach fills as well as bridge piers may be founded on steel 'H' section piles equipped with reinforced tips driven to competent bedrock. For estimating purposes, 'H' piles driven to refusal into bedrock, at approximate tip elevations of 101 to 99 for Site 10-320 and elevation 103 for Site 10-321, can be designed for the maximum allowable compressive loading per pile section. Pile driving should be controlled in the field by the MTC Hiley Formula using a minimum driving energy of 50 kJ per blow.

Alternatively, the abutments can be founded on an engineered fill consisting of a well compacted Granular 'A' core designed as per MTC specifications. An allowable design loading of 240 kPa can be achieved for spread footings designed in this manner.

Minimal settlement/stability problems are anticipated for the approach embankment fills and slopes provided they are constructed to a 2:1 geometry.

continued...../2

We trust the information provided in this memo and the accompanying report is sufficient for your requirements. Should further discussions be warranted, please feel free to contact this Section.

TJK:ea

T.J. Kazmierowski
Project Foundations Engineer

Encl.

cc: G.C.E. Burkhardt
R.D. Gunter
I.V. Oliver
D.E. Thrasher
C. Grebski
B.J. Giroux
R. Hore

memorandum



To: G. Al-Bazi
Design Engineer
7th Floor, Atrium Tower

Date: 1990 10 16

From: Foundation Design Section
Room 315, Central Building

Re: Q.E.W. SBL - Ramp S. to Hwy. 403 Underpass
W.P. 83-74-29, Site 10-321
Hwy. 403, District 4, Burlington

The final drawing No's 1, 3 and 4 for the above noted project were reviewed and the following comments are submitted.

- 1) It appears that the piles for the north and south abutments will have to be driven through 1.0 m to 1.5 m of shale bedrock.
- 2) Based on the bedrock condition, the actual pile length may be expected to vary substantially from the pile lengths indicated in the drawing No: 4.
- 3) The working concrete pad for pier foundations should be placed within 6 hours of exposure.

A handwritten signature in dark ink, appearing to read "P. Payer".

P. Payer, P. Eng.
Sr. Foundation Engineer

for

M. Devata, P. Eng.
Chief Foundation Engineer

MD/PP/jb

SEND
TO

G. AL-BAZI

STRUCTURAL OFFICE

7TH FLOOR, ABRIUM TOWER

FROM

P. PAYER FOUNDATION DESIGN

DATE

90 05 01

SUBJECT

RECOMMENDED FOOTING LEVELS, WP. 83-74-29.

PILE TIP ELEVATIONS

NORTH ABUT. EL. 104.5, SOUTH ABUT. 103.6

ALTERNATIVE: ABUTMENTS ON COMPACTED GRANULAR
'A' COREPIERS: SPREAD FOOTINGS ON BEDROCK

FOOTING BASE LEVELS: NORTH PIER: 104.0 OR LOWER,

SOUTH PIER: EL. 104.2 OR LOWER

THE FROST PROTECTION REQUIREMENT IS A MINIMUM
OF 1.2m OF EARTH COVER.

P. Payer

REPLY

REPLY FROM

REPLY DATE



Memorandum

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

From: Pavement & Foundation Design Section
Room 313, Central Building

Attention:

Date: 81 02 03

Our File Ref.

In Reply to

83-7729

Subject:

Q.E.W. South - Hwy. 403 W Ramp
Over Q.E.W. S.B.L.
Site 10-321, W.P. 83-74-29
District 4, Hamilton

Golder Associates, geotechnical consulting engineers, have completed the foundation investigation program for the above mentioned project and have submitted to us a draft copy of the final report for comments. In order to satisfy your scheduling and preliminary design requirements, this letter summarizes the subsurface conditions encountered across the site and presents design recommendations interpreted from the consultant's draft report. The complete foundation investigation report and drawing for this site will be forwarded to you upon its receipt and review by this Section.

Briefly, the predominate subsurface deposit underlying the site consists of a heavily overconsolidated silty clay of low plasticity containing a trace of sand and gravel with numerous shale fragments. 'N' values ranging from 17 to 39 blows per 0.3 m indicate a stiff to hard consistency for this residual soil. Shale bedrock was encountered at depths ranging from 1.5 to 1.8 metres below ground surface corresponding to elevations 104.7 and 103.8 respectively. In general, the upper 1 metre of the shale is highly weathered. Groundwater levels were found to vary between elevations 104.4 and 105.3, generally indicating a southward gradient across the site.

Recommendations pertaining to the structure foundations and related earthworks are summarized as follows.

Pier foundations may be founded on spread footings located on the weathered shale interface. For design estimating purposes, footings found at elevations ranging from 104.7 on the north extreme to 103.8 on the south can be designed for an allowable bearing pressure of 400 kPa. Mass concrete may be used to effectively raise the founding elevation of the spread footings from weathered shale to an economic level.

Perched abutments in the approach fills and also bridge piers may be founded on steel 'H' section piles equipped with reinforced tips driven to competent bedrock. For estimating purposes, 'H' piles driven to refusal into bedrock (approx. tip elevation of 103) can be designed for the maximum allowable compressive loading per pile section.

Pile driving should be controlled by the MTC Hiley Formula using a minimum driving energy of 50 kJ per blow.

Alternatively, the abutments can be founded on an engineered fill consisting of a well compacted Granular 'A' core designed as per MTC specifications. An allowable design loading of 240 kPa can be achieved for spread footings designed in this manner.

All footings and pier caps should be designed with a minimum of 1.2 metres of earth cover for frost protection purposes.

Provisions should be made to pour a minimum 0.15 m thick slab of lean concrete over the base of any foundation excavation carried down to bedrock immediately upon completion of the excavation.

In order to resist lateral forces acting on the abutment wall, frictional forces between the footing and the underlying bedrock can be calculated using a coefficient of friction of 0.55. The lateral earth pressure exerted on the abutment by the granular backfill can be computed assuming a unit weight of 20.5 kN/m³ for the backfill and a coefficient of earth pressure ' K_0 ' of 0.5. Backfilling operations and drainage measures should be carried out as per current MTC standards.

Minimal settlement/stability problems are anticipated for the approach embankment fills and slopes provided they are constructed to a 2:1 geometry.

In consideration of the relatively impervious nature of the residual soil, no extensive dewatering systems are required. Groundwater seepage into braced excavations should be controlled by pumping from perimeter sumps.

We trust the information provided is sufficient in scope for your immediate requirements. Should further discussion be warranted, please feel free to contact this Section.



T. Kazmierowski
Project Foundations Engineer

TK:ea

cc: R. Fitzgibbon

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 3015-123

DIST. 4 REGION

W.P. No. 83-74-28

CONT. No. 91-22

W. O. No.

STR. SITE No. 10-320

HWY. No. QEW/403

LOCATION Proposed Bridge, Interchange

No of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

FOUNDATION INVESTIGATION REPORT

CONTRACT NO 91-22



Ministry of
Transportation

CONT 91-22

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Note: For purposes of the contract, this report supercedes 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/0.3 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:

R Q D (%)	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

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

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 = $\frac{c_u}{\tau_r}$

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						



Golder Associates

CONSULTING GEOTECHNICAL AND MINING ENGINEERS

REPORT
TO

MINISTRY OF TRANSPORTATION
AND COMMUNICATIONS

FOUNDATION INVESTIGATION
PROPOSED OVERPASS BRIDGES AT Q.E.W./
HWY. 403

WP 83-74-28/29

DISTRICT 4

1.0 INTRODUCTION

Golder Associates have been retained by the Ministry of Transportation and Communications (letter dated December 5, 1980) to carry out a foundation investigation for two proposed overpass bridges on the QEW/403 Interchange in Burlington, Ontario (overall W.P. 837407).

The purpose of the investigation was to determine the subsurface conditions at the site and based on these data, to provide engineering recommendations for the geotechnical design of the foundations for the proposed structures.

The investigation was carried out, and this report was prepared, in accordance with Golder Associates' letter, dated December 23, 1980.

2.0 DESCRIPTION OF PROJECT

Details of the project were provided during a meeting between Mr. Selby of the Ministry of Transportation and Communications, and Messrs. Davis and Busbridge of Golder Associates on December 15, 1980. Additional details were provided on two plans titled "Bridge Site, Proposed Northbound QEW Underpass at Ramp QEW-S to Hwy. 403" designated Site 10-320, W.P. 837428 dated September 30, 1980, and "Bridge Site, Proposed Southbound QEW Underpass at Ramp QEW-S to Hwy. 403" designated Site 10-321, W.P. 837429 dated October 1, 1980, and in an M.T.C. memorandum dated October 27, 1980. It is understood that the above mentioned projects form part of overall W.P. 837407.

It is understood that at Site 10-320, the proposed bridge will be a four span post-tensioned type with spans of approximately 22 m, 45 m, 39 m and 22 m. It will allow for QEW northbound traffic to proceed westerly along Hwy. 403. The centre column is to be located at the median of the future QEW.

At Site 10-321 it is understood that the proposed bridge will be a three span post-tensioned type with spans of approximately 20 m, 40 m and 20 m. It will allow for traffic carried by the previous bridge deck to overpass the future QEW southbound lanes and proceed westerly along Hwy. 403.

The approximate locations of the footings were shown in red on the two plans provided, along with profiles of both QEW and the ramps under consideration in this area.

3.0 SITE AND GEOLOGY

The proposed bridges are to be located along the QEW, south of the North Service Road and west of Brant Street in the City of Burlington, Ontario. The topography at the site is generally flat lying having an elevation about 106 m (Geodetic). Immediately to the north of the site the land rises towards the Niagara Escarpment.

The site is located in the physiographic region known as the Iroquois Plain, consisting of a narrow strip of land along the shores of the present Lake Ontario. This level plain was formed by post-glacial Lake Iroquois which then occupied the Lake Ontario basin. In the Burlington area the surficial soils in this plain consist of beach sands, clayey silt till and/or residual red clayey silt derived from weathering of the underlying Queenston shale bedrock. The Queenston shale formation consists of thinly bedded red clay shale with occasional bands of grey limestone.

4.0 INVESTIGATION PROCEDURE

The field work for this investigation was carried out between December 22 and 31, 1980. The elevations of the boreholes were determined on January 5, 1981. During this time nine boreholes were put down at the two sites (Drawings 837428-A* and 837429-A)** using a Type 5.3.i drillrig supplied and operated by Master Soil Investigations Ltd., of Toronto, a specialist drilling contractor. Within the overburden soils the boreholes were advanced with solid stem augers. In each

* DWG NO 3 OF THE CONTRACT DWG'S

** " " 2 " " " "

boring, standard penetration tests were carried out at 0.76 m intervals of depth, and samples were obtained using a standard 50 mm O.D. split spoon sampler, which was advanced by a 63.5 kg mass falling freely for 0.76 m. In each boring, bedrock was cored for depths of between 2.8 m to 3.8 m in BXL size. Details of the drilling and sampling operations are summarized on the Record of Borehole sheets. A filtered standpipe was sealed into each boring to allow monitoring of the groundwater level.

The field work was supervised throughout by a member of Golder Associates' engineering staff, who located the borings in the field, cleared underground services, directed the drilling and sampling operations, logged the borings and cared for the samples. The borehole locations were established by tape measurement. The ground surface elevations at each boring was determined relative to an M.T.C. survey monument (Drawing 837428-A)*. The elevation of this control point was provided by a member from the M.T.C. staff on January 8, 1981. It is understood that all ground surface elevations are referred to Geodetic datum.

Following field identification and logging, all the samples obtained during the investigation were placed in air-tight containers and brought to our laboratory where they were examined in detail. Representative samples of the soil were tested to determine their index properties.

5.0 SUBSURFACE CONDITIONS

The detailed stratigraphy encountered in each of the boreholes together with the results of laboratory tests carried out on representative samples of the soil strata are given on the attached Record of Borehole sheets and on Figures 1 to 3. The locations of the boreholes and the simplified stratigraphy at the boreholes are shown on Drawings 837428-A* and 837429-A.** It should be noted that the stratigraphic boundaries indicated on the borehole logs and longitudinal sections are inferred from a transition from one soil type

* DWG NO 3 OF THE CONTRACT DWG'S

** " " 2 " " " "

to another and do not necessarily indicate an exact plane of geologic change. Further, the subsurface conditions may vary between boreholes.

5.1 Site 10-320

At the locations of Boreholes 5, 6 and 8, up to 0.3 m of topsoil was encountered at ground surface. A layer of granular material comprising crushed stone (sand and gravel sizes) was encountered at Borehole 7 and extends to a depth of 1.4 m (Elev. 104.8 m). This material forms part of the shoulder of the existing Highway 403 exit ramp to the QEW. The topsoil at Boreholes 5, 6 and 8, the granular fill at Borehole 7 as well as ground surface at Borehole 9 are underlain by a layer of clayey silt containing some sand and gravel, pieces of red brick and occasional thin lenses of black organic matter. This fill varies in thickness from 0.6 m at Boreholes 5 to 2.0 m at Borehole 7. The fill is underlain by hard (N values greater than 30) clayey silt containing a trace of sand and gravel to sandy silt containing some gravel, with red shale fragments throughout.

The clayey silt material has a grain size distribution (Figures 1 and 2) similar to that of a glacial till. However, the coarser fraction of the soil is angular and easily friable. This material has the characteristics of a residual soil (soil material with the original texture, structure and mineralogy of the rock completely destroyed) rather than the matrix of a glacial till. It extends to a depth of about 2.3 m (between Elev. 100.1 m to 103.2 m) below ground surface except at Borehole 7 where it extends to 4.4 m (Elev. 101.8 m) below ground surface. The fill has a grain size distribution similar to that of the residual soil (Figure 1 - BH7, SA 3) and is probably local material placed during previous construction activities.

The water content of the sandy silt is about 10 per cent and that of the clayey silt is about 17 per cent. Both

materials (forming the residual soil) exhibit low plasticities with liquid limits between 16 to 22 per cent and a plasticity index of about 2 (Figure 3). The residual soil encountered at Boreholes 5 and 9 is more granular (Figure 2) than that of Boreholes 6, 7 and 8, possibly due to it containing more weathered shale fragments. This material is underlain by highly weathered to faintly weathered, reddish brown, weak to strong Queenston shale. The shale is irregularly banded with grey limestone layers about 80 mm in thickness and an occasional thin seam of red clay. The core recovery was generally in excess of 70 per cent and the Rock Quality Designations (RQD) lies between zero and 80 per cent, the higher quality being recorded for core recovered about 2 m below the overburden/bedrock interface.

As is evidenced from the profile shown on Drawing 837428-A* ground surface and the various stratigraphic units slope gently from north (BH 5) to south (BH 9). The top surface of the residual soil also slopes towards the south but is more erratic due to the surface having been changed by previous construction activities and fill placement. The elevation of Borehole 7 is higher than the other boreholes in the same general area due to it being located near the southern shoulder of the exit ramp from Hwy. 403.

The groundwater surface measured in the standpipes also slopes towards the south generally following the ground surface topography.

5.2 Site 10-321

At the location of Boreholes 1 to 4 the ground surface is underlain by between 0.12 and 0.36 m of topsoil. At Boreholes 3 and 4, the topsoil overlies a layer of fill composed of clayey silt containing some sand and gravel, pieces of red brick and occasional thin lenses of black organic matter. The fill extends to a depth of 1.1 and 0.5 m (Elev. 104.9 and 105.1 m) below ground surface at the location of these two boreholes. The topsoil at Boreholes 1 and 2 and the fill at

* DWG NO 3 OF THE CONTRACT DWG'S

Boreholes 3 and 4 is underlain by between 0.7 and 1.6 m of stiff to hard (N values 17 to 39) reddish brown clayey silt containing a trace of sand and gravel and numerous red shale fragments, and is considered to be residual soil. The residual soil was penetrated to about 1.5 to 1.8 m (Elev. 103.8 to 104.7 m) below ground surface at which depths refusal to augering was encountered. The higher 'N' values given on the Record of Borehole sheets and on the profile shown on Drawing 837429-A* were obtained at the overburden/bedrock contact.

The water content of the residual soil lies between 11 and 16 per cent which is below the plastic limit of the material and indicative of a heavily overconsolidated soil. The material exhibits low plasticity with a plasticity index of about 10 (Figure 3).

Bedrock was extracted by BXL rock coring techniques. The bedrock was found to be a highly weathered to faintly weathered at depth, reddish brown, weak to strong at depth, Queenston shale. The shale is irregularly banded with grey limestone layers about 80 mm in thickness, and is occasionally intercepted by thin seams of red clay. The core recovery was about 73 per cent and the RQD was between zero and 60 per cent and generally below 50 per cent. This indicates that the shale bedrock is of generally poor to fair quality.

The groundwater level measured within the standpipes slopes towards the south, generally following the surface topography. Although the water level is indicated as being higher at Borehole 3 than at Borehole 2 this may be due to an interceptor ditch located near Borehole 2 thereby depressing the water level in this area.

* DWG NO 2 OF THE CONTRACT DWG'S

NOTE: The preceding report is a copy of the factual information from the Foundation Investigation Report prepared by Golder Associates Ltd. (consulting geotechnical engineers for this project), under the technical supervision of the MTO Foundation Design Section.

RECORD OF BOREHOLE No.1

METRIC

W P 83-74-29 LOCATION Co-ords 4,799,746N: 278,076 E (STA 8+ 921) ORIGINATED BY A.H.T.
 DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
 DATUM Geodetic DATE December 22, 1980 CHECKED BY J.S.K.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
106.24	Ground Level																
0.00	Topsoil																
105.88	Clayey Silt with shale fragments (Residual soil). Hard.		1	SS	39												0 6 70 24
0.36	Red and Greenish Grey.		2	SS	50/107												
104.72	Shale Bedrock.																
1.52	Highly weathered reddish brown, fine grained, weak, irregularly banded with grey lime- stone layers about 80mm thick. 76mm clay seam at Elev. 103.3 m.		3	R.C.													RQD 31%
			4	BXL	89%												RQD 9%
101.70																	
4.54	End of Borehole.																W.L. elev 105.17 on Jan.5, 1981

RECORD OF BOREHOLE No. 2

METRIC

W P 83-74-29 LOCATION Co-ords 4,799,727 N; 278,084 E (STA 8+942.5) ORIGINATED BY A.H.T.
 DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
 DATUM Geodetic DATE December 23, 1980 CHECKED BY J. Smith

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
106.33	Ground Level																
106.08	Topsoil																
0.24	Clayey Silt, some shale fragments (residual soil).																
	Very Stiff.																
104.50	Reddish Brown.																
1.83	Shale Bedrock, highly weathered, reddish brown, fine grained, weak.		1	SS	17												
	32mm clay seam at Elev. 103.7 m.		2	SS	25												
103.28	Shale Bedrock.		3	RC BXL	91%												
3.05	Faintly weathered reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		4	RC BXL	100%												
101.21	End of Borehole.		5	RC BXL	100%												
5.12																	

METRIC

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100					
								SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					
105.96	Ground Level												
0.00	Topsoil												
0.12	Clayey Silt (Fill).												
104.89	Hard. brown to Black.												
1.07	Clayey silt, with shale fragments (Residual Soil)	*	1	SS	17								
104.19	Hard, Reddish brown.	*	2	SS	115/279 mm								
1.77	Shale Bedrock. Highly weathered. Redish brown, fine grained, weak.		3	RC BXL	73%								RQD 0%
103.16	Shale Bedrock. Faintly weathered, reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		4	RC BXL	92%								RQD 0%
			5	RC BXL	100%								RQD 60%
101.33													
4.63	End of Borehole.												W.L. elev. 104.53 on Jan. 5/81

RECORD OF BOREHOLE No.4

METRIC

W P 83-74-29 LOCATION Co-ords 4,799,673 N; 278,111 E (STA 9+002.5) ORIGINATED BY A.H.T.
DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
DATUM Geodetic DATE December 23 & 24, 1980 CHECKED BY J.C.

[illegible]

RECORD OF BOREHOLE No. 5

METRIC

W P 83-74-28 LOCATION Co-ords. 4,799,633 N; 278,130 E (STA 9+047) ORIGINATED BY A.H.T.
 DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
 DATUM Geodetic DATE December 29, 1980 CHECKED BY J.V.C.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100		
105.42	Ground Level													
0.00	Topsoil													
0.30	Clayey to Sandy Silt (Fill).		1	SS	15		105							
104.65	Stiff Red to Dark Brown													
0.91	Sandy silt, some gravel, trace clay (Residual Soil).		2	SS	28									
							Backfill							
							104							
			3	SS	76									16 34 42 8
103.27	Dense, Reddish Brown.													
			4	SS	55/100		103							RQD 0%
2.29	Shale Bedrock, Slightly Weathered. Reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		5	RC	11%									
			6	BXL	97%		102							RQD 48%
101.29	Shale Bedrock. Faintly weathered reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		7	RC	101%		101							RQD 73%
							Pea Gravel							
99.63	End of Borehole.						100							W.L. Elev. 104.87 on Jan. 5/81
							99							

RECORD OF BOREHOLE No.6

METRIC

W P 83-74-28 LOCATION Co-ords, 4,799,610N; 278,139E (STA. 9+071) ORIGINATED BY A.H.T.
DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
DATUM Geodetic DATE December 29, 1980 CHECKED BY J.C.C.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100				
105.47	Ground Level															
0.0	Topsoil															
0.15	Clayey to Sandy Silt, some gravel (Fill).		1	SS	17	Seal	105									
			2	SS	18	Backfill	104									
103.67	Compact, Brown.		3	SS	38											
1.80	Clayey Silt, some gravel (Residual Soil).															
103.13	Hard. Reddish Brown.		4	SS	70/152	Seal	103									
2.34	Shale Bedrock. Moderately weathered reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		5	RC	98%		102									RQD 23%
101.63				BXL												
3.84	Shale Bedrock. Faintly weathered reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		6	RC	100%	Fea Gravel	101									RQD 57%
99.80				BXL			100									W.L. elev. 103.85 on Jan. 5/81
5.67	End of Borehole.						99									

RECORD OF BOREHOLE No. 7

METRIC

W P 83-74-28 LOCATION Co-ords. 4,799,575N; 278,151E (STA. 9+108) ORIGINATED BY A.H.T.
DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
DATUM Geodetic DATE December 30, 1980 CHECKED BY J. L. C.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
106.22	Ground Level																
0.0	Crushed Stone (Sand and Gravel sizes) (Fill).					Seal	106										
104.85	Very Dense, Brown.		1	SS	59		105										
1.37	Clayey Silt, some sand, trace gravel (Fill).		2	SS	44		104										
	Stiff to Hard.		3	SS	13		103										2 20 57 21
102.84	Brown.		4	SS	40		102										
3.38	Clayey Silt, some sand, trace gravel and shale fragments (Residual Soil).		5	SS	60/152		101										
101.80	Hard. Reddish Brown.		6	SS	60/152		100										
4.42	Shale Bedrock. Highly weathered. Reddish brown. Fine grained. Weak.		7	RC	39%		99										RQD 0%
100.73			8	BXL	120%		98										RQD 53%
5.49	Shale Bedrock. Moderately weathered reddish brown, fine grained, strong. Irregular banded with grey limestone layers about 80 mm thick.		9	RC	78%												RQD 41%
99.15			10	BXL	86%												RQD 86%
7.07	Shale Bedrock. Faintly weathered. Reddish brown with irregular grey limestone bands.																
98.08	Fine grained. Strong.																
8.14	End of Borehole.																W.L. elev. 102.44 on Jan. 5/81

RECORD OF BOREHOLE No.8

METRIC

W P 83-74-28 LOCATION Co-ords. 4,799,531N; 278,161E (STA. 9+152) ORIGINATED BY A.H.T.
 DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
 DATUM Geodetic DATE December 29 & 30, 1980 CHECKED BY J.W.C.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
103.01	Ground Level																GR SA SI CL
0.00																	
102.70	Topsoil																
0.31	Sandy Silt to Clayey Silt (Fill). Very Stiff. Brown.																
102.06																	
0.95	Sandy Silt to Clayey Silt with gravel (Residual Soil).		1	SS	35		102										
101.18	Hard. Reddish Brown.		2	SS	65/152	mm											
1.83	Shale Bedrock. Highly weathered. Reddish brown with irregular grey limestone bands about 80 mm thick. Fine grained. Weak.		3	RC	44%		101										RQD 0%
			4	BXL	100%		100										RQD 34%
99.11																	
3.90	Shale Bedrock. Slightly weathered. Reddish brown with irregular grey lime- stone bands about 80 mm thick. 75 mm clay seam at Elev. 99.1 m. Fine grained. Strong.		5	RC	99%		99										RQD 45%
			6	BXL	100%												RQD 100%
97.68			7	RC	100%		98										RQD 100%
				BXL													
5.33	End of Borehole.						97										W.L. elev. 102.13 on Jan. 5/81

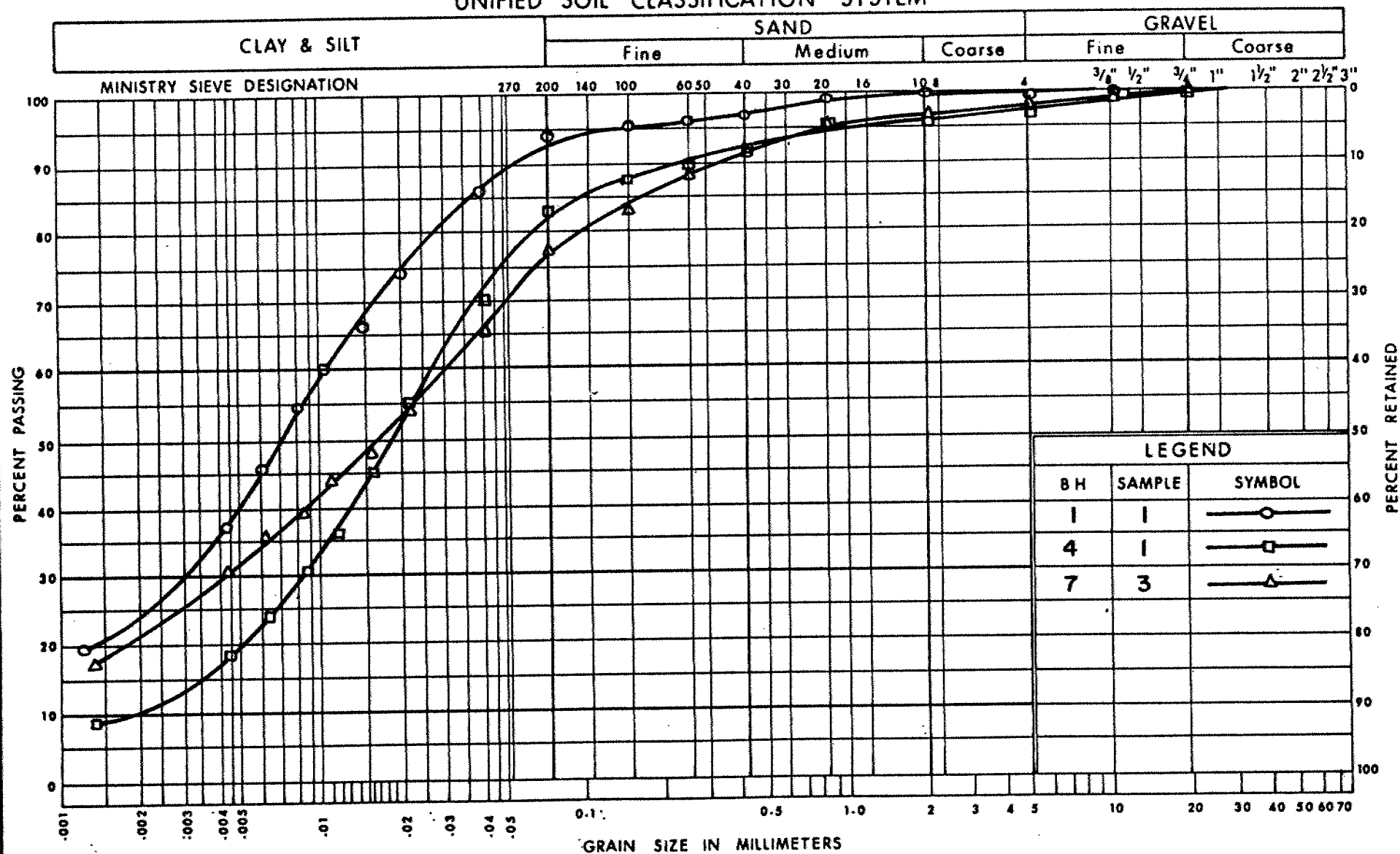
RECORD OF BOREHOLE No 9

METRIC

W P 83-74-28 LOCATION Co-ords. 4,799,508N; 278,165E (STA. 9+175) ORIGINATED BY A.H.T.
 DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
 DATUM Geodetic DATE December 30 & 31, 1980 CHECKED BY J.M.C.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
102.44	Ground Level																GR SA SI CL
0.00	Clayey Silt to Sandy Silt, some gravel (Fill). Stiff.					Seal	102										
101.37	Dark brown to black.		1	SS	19	Backfill	101										12 31 53 4
1.07	Sandy Silt, some gravel, trace clay (Residual Soil).		2	SS	86												
100.15	v. dense. Reddish Brown.					Seal	100										RQD 35%
2.29	Shale bedrock, slightly weathered reddish brown with grey limestone bands. Short vertical fracture at elev. 99.3 m.		3	SS	60/75												RQD 50%
99.09	Fine grained. Strong.		4	RC	88%												
			5	RC	98%		99										
3.35	Shale bedrock, faintly weathered. Reddish brown with grey limestone bands about 80 mm thick. Clay seam at elev. 98.4 m.			BXL													RQD 70%
	Fine grained. Strong.		6	RC	98%		98										
96.95				BXL													
							97										W.L. elev. 101.74 on Jan. 5/81
5.49	End of Borehole.						96										

UNIFIED SOIL CLASSIFICATION SYSTEM



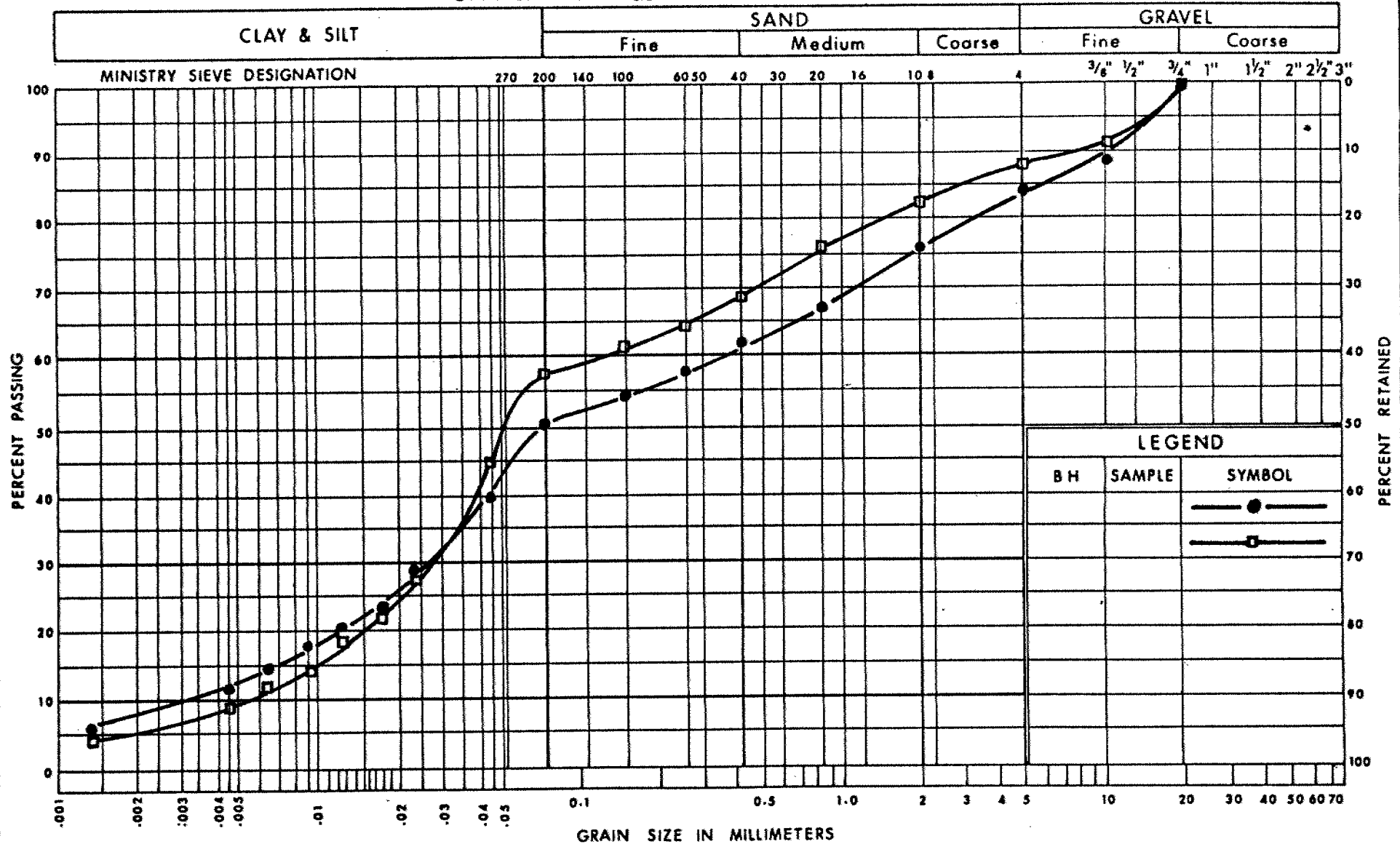
Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION
CLAYEY SILT, TRACE SAND (RESIDUAL SOIL)

FIG No 1

W P 83-74-28/29

UNIFIED SOIL CLASSIFICATION SYSTEM

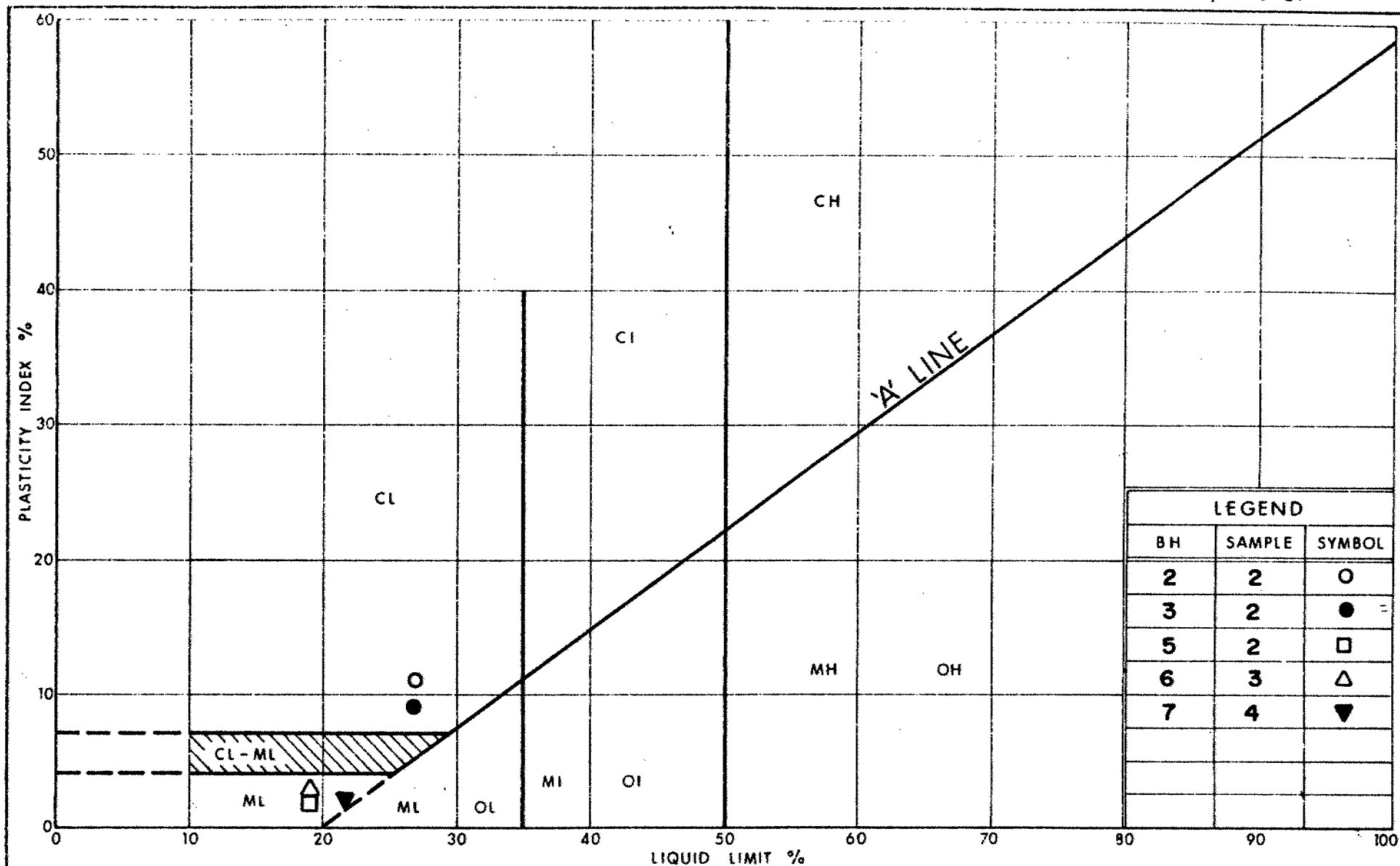


Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION SANDY SILT (RESIDUAL SOIL)

FIG No 2

W P 83-74-28/29



LEGEND		
BH	SAMPLE	SYMBOL
2	2	○
3	2	●
5	2	□
6	3	△
7	4	▼



Ministry of
Transportation and
Communications

PLASTICITY CHART

FIG No **3**

W P 83-74-28/29

For

Q.E.W. S - 403 E Ramp over North Service Road

W.P. 199-77-12, Site 10-1337-339

District 4, BurlingtonINTRODUCTION

This report summarizes the factual information obtained from a foundation investigation performed at the above-mentioned site. Fieldwork consisted of four sampled boreholes and eight dynamic cone penetration tests advanced between 85 02 14 and 85 02 19. A track mounted auger machine was employed for the investigation. Borings were advanced for depths ranging from 2.9 m to 12.1 m. Bedrock was cored utilizing BXL size in all four boreholes.

SITE DESCRIPTION

The site is located approximately 550 m west of existing Brant St. and about 130 m north of the existing North Service Road in the City of Burlington, Regional Municipality of Halton.

It is proposed to construct a three span precast concrete structure to accommodate traffic movements from the Q.E.W. south to the future 403 eastbound over the relocated North Service Road. This site has been used as a borrow area for existing contracts and therefore the proposed relocated North Service Road, which is located in a cut in this vicinity, has been excavated approximately to subgrade.

The site is located in the physiographic region known as the South Slope. The area is characterized by a ground moraine of limited relief. The underlying bedrock is a red shale with siltstone, of the Queenston Formation.

SUBSURFACE CONDITIONSGeneral

This report must be read in conjunction with the Record of Borehole Sheets located in the Appendix as well as Dwg. #1997712-A* which shows the locations and elevations of the borings along with an estimated stratigraphical profile based on the borehole data.

The subsoil conditions are fairly uniform across the site. Exposed at ground surface at boreholes 1, 3 and 7, and underlying approximately 1.0 m of silty clay fill at borehole 5, is a heterogeneous mixture of silty clay containing varying proportions of sand and gravel and occasional cobbles and boulders. This deposit overlies bedrock.

* DWG NO 2 OF THE CONTRACT DWG'S

The various soil types encountered are described in the following paragraphs.

Fill

An approximately 1.0 m thick layer of silty clay, trace organics and gravel was encountered at borehole 5. Based on one Standard Penetration Test 'N' value, the consistency of this deposit is considered to be stiff.

Heterogeneous Mixture of Silty Clay, Sand and Gravel (Glacial Till)

This deposit is the predominant soil type across the site. It was encountered in all boreholes and ranged in thickness from 6.2 m at borehole 7 to 9.4 m at borehole 1. It consists of a heterogeneous mixture of silty clay with varying proportions of sand and gravel. Occasional cobbles and boulders were encountered during the investigation.

The results of water content and Atterberg Limit testing are plotted on the Plasticity Chart, Figure #1 and are summarized as follows:

		Range	Average
Water Content	(W)%	8-18	13
Liquid Limit	(W _L)%	25-28	26
Plastic Limit	(W _p)%	15-17	16
Plasticity Index	(I _p)%	9-12	10

Grain size distribution tests were carried out on representative samples and the results of these tests are shown in envelope form on Figure #2 in the Appendix.

Standard Penetration Test 'N' values ranged from 13 to over 100 blows per 0.3 m penetration. Based on these results, the consistency of this deposit varies from stiff to hard.

Bedrock

Bedrock was proven by obtaining up to 3.0 m of BXL rock core.

Generally, the bedrock is a red shale with green unweathered siltstone (approx. 10%) of the Queenston Formation. The upper portion of the bedrock is highly weathered. A detailed description of the rock core was prepared by Mr. E. Magni, M.T.C. Geologist and his report is located in the Appendix.

Groundwater

The groundwater level was not encountered during the drilling operations.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of Mr. R. Thomas, Student Specialist Engineer, utilizing equipment owned and operated by Atcost Soil Drilling Inc., Concord. This report was written by Mr. B. Ruck, Project Foundations Engineer and reviewed by Mr. K. Selby, Chief Foundations Engineer (West).



P. Payer, P. Eng.
Sr. Foundation Engineer

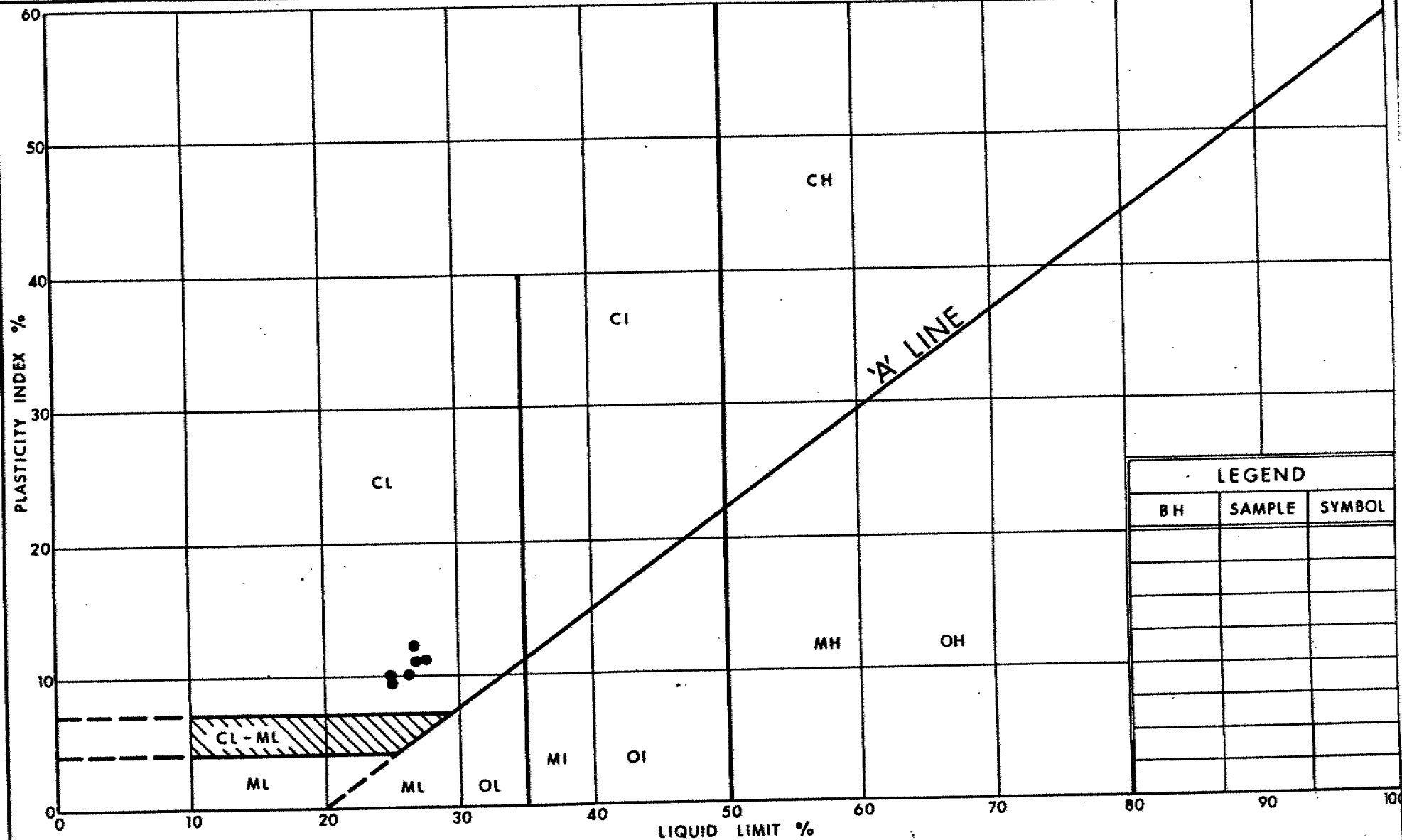
M. Devata, P. Eng.
Chief Foundation Engineer

APPENDIX

DESCRIPTION OF ROCK CORE - W.P. 199-77-12

BOREHOLE NUMBER				CORE DESCRIPTION	
	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
1	10.49-12.07	94	74	10.49-10.67	Shale (100%), red, highly weathered
				10.67-12.07	Shale (90%), red, unweathered, medium spaced joints, with siltstone (10%), green, unweathered; highly weathered shale layer 11.76 - 11.86 m
3	6.76- 8.33	95	52	7.76- 9.78	Shale (90%), red, slightly weathered to 7.06 m, becoming unweathered, medium spaced joints, with siltstone (10%), green, unweathered
	8.33- 9.78	100	100		
5	8.41- 9.88	100	72	8.41- 9.88	Shale (90%), red, unweathered, medium spaced joints, with siltstone (10%), green, unweathered
7	6.84- 8.33	97	73	6.84- 8.33	Shale (90%), red, unweathered, medium spaced joints, with siltstone (10%), green, unweathered; highly weathered zone from 8.0 - 8.05 m

* CR= CORE RECOVERY ; RQD = ROCK QUALITY DESIGNATION



LEGEND		
BH	SAMPLE	SYMBOL

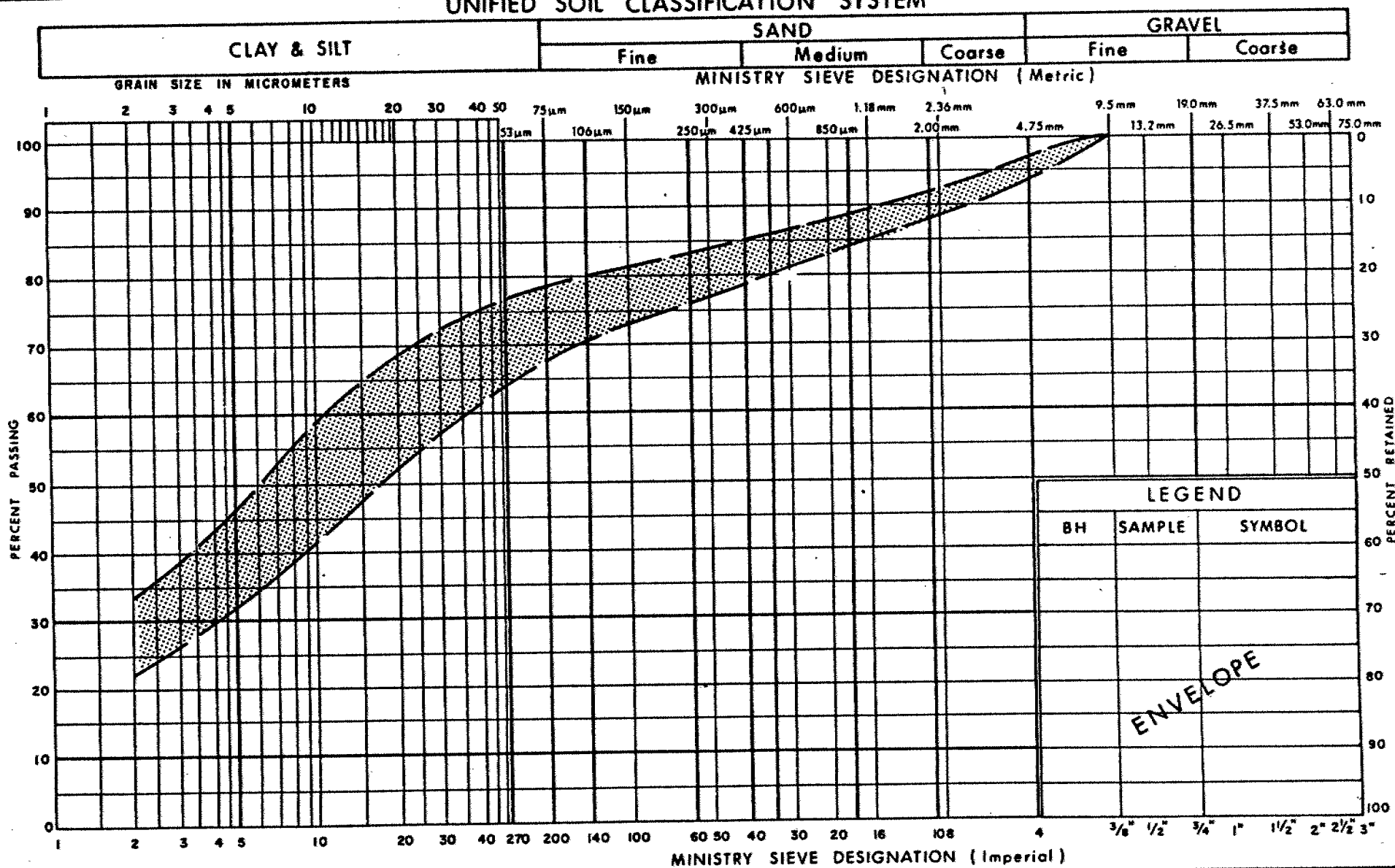


Ministry of
Transportation and
Communications

PLASTICITY CHART HETEROGENEOUS MIXTURE OF SILTY CLAY, SAND & GRAVEL (Glacial Till)

FIG No 1
W P 199-77-12

UNIFIED SOIL CLASSIFICATION SYSTEM



**Ministry of
Transportation and
Communications**

GRAIN SIZE DISTRIBUTION

HETEROGENEOUS MIXTURE OF SILTY CLAY, SAND & GRAVEL
(Glacial Till)

FIG No 2

W P 199-77-12

RECORD OF BOREHOLE No 1

METRIC

W P 199-77-12 LOCATION N 4 799 934 E 277 987 ORIGINATED BY RT
DIST 4 HWY 403 BOREHOLE TYPE Solid Stem Auger & BXL Rock Coring COMPILED BY BR
DATUM Geodetic DATE 85 02 19 CHECKED BY *162*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	SHEAR STRENGTH ○ 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									
117.1	Ground Surface													
0.0			1	SS	44		116							
			2	SS	21									
			3	SS	17									
	Heterogeneous Mixture of Silty Clay Sand and Gravel		4	SS	18		114							
			5	SS	13									
	Stiff to Hard (Glacial Till)		6	SS	24		112							
			7	SS	29									
			8	SS	50		110							
			9	SS	100	30 cm								
107.7			10	SS	100	8 cm	108							
9.4	Bedrock						106							
	Weathered Sound (Queenston Shale)		11	BXL RC	REC 94%									RQD 74%
105.0														
12.1	End of Borehole						104							
	* Water Level Not Encountered													

RECORD OF BOREHOLE No 2										METRIC			
W P 199-77-12		LOCATION N 4 799 921 E 277 992				ORIGINATED BY RT							
DIST 4 HWY 403		BOREHOLE TYPE Dynamic Cone Penetration Test				COMPILED BY BR							
DATUM Geodetic		DATE 85 02 18				CHECKED BY <i>[Signature]</i>							
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					
113.4	Ground Surface												
0.0													
110.5													
2.9	End of Cone Test												

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 3

METRIC

W P 199-77-12 LOCATION N 4 799 902 E 277 998 ORIGINATED BY RT
DIST 4 HWY 403 BOREHOLE TYPE Solid Stem Auger - BXL Rock Coring COMPILED BY BR
DATUM Geodetic DATE 85 02 15 CHECKED BY *h*

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
113.0	Ground Surface															
0.0	Heterogeneous Mixture of Silty Clay Sand and Gravel Very Stiff to Hard (Glacial Till)		1	SS	20											
			2	SS	21											
			3	SS	38											
			4	SS	65											
			5	SS	81											
			6	SS	100	20 cm										
			7	SS	100	15 cm										
106.7	Weathered Bedrock (Queenston Shale)		8	SS	100	15 cm										
6.3			9	BXL RC	REC 95%									RQD 52%		
103.2			10	BXL RC	REC 100%									RQD 100%		
9.8	End of Borehole * Water Level not Encountered															

+3, x5: Numbers refer to
Sensitivity

20
15 \div 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 4

METRIC

W P 199-77-12 LOCATION N 4 799 890 E 278 000 ORIGINATED BY RT
DIST 4 HWY 403 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY BR
DATUM Geodetic DATE 85 02 14 CHECKED BY *[Signature]*

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	20					
115.5	Ground Surface												
0.0													
112.1													
3.4	End of Cone Test												

RECORD OF BOREHOLE No 5

METRIC

W P 199-77-12 LOCATION N 4 799 893 E 278 010 ORIGINATED BY RT
DIST 4 HWY 403 BOREHOLE TYPE Solid Stem Auger & BXL Rock Coring COMPILED BY BR
DATUM Geodetic DATE 85 02 14 CHECKED BY *10*

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					
115.1	Ground Surface												
0.0	Fill - Silty Clay trace organics and gravel Stiff		1	SS	13								
114.1			2	SS	28								
1.0			3	SS	26								
	Heterogeneous Mixture of Silty Clay Sand and Gravel		4	SS	37								
	Very Stiff to Hard		5	SS	37								
	Occasional Boulders		6	SS	33								
	Grey (Glacial Till)		7	SS	73/20 cm								4 25 47 24
107.2			8	SS	100/13 cm								
7.9	Weathered Sound		9	SS	100/5 cm								
	Bedrock		10	BXL RC	REC 100%								RQD 72%
105.2	(Queenston Shale)												
9.9	End of Borehole												

RECORD OF BOREHOLE No 7

METRIC

W P 199-77-12 LOCATION N 4 799 923 E 277 996 ORIGINATED BY RT
 DIST 4 HWY 403 BOREHOLE TYPE Solid Stem Auger - BXL Rock Coring COMPILED BY BR
 DATUM Geodetic DATE 85 02 18 CHECKED BY SB

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					
113.4	Ground Surface												
0.0	Heterogeneous Mixture of Silty Clay Sand and Gravel Very Stiff to Hard (Glacial Till)		1	SS	19								
			2	SS	20								
			3	SS	27								
			4	SS	84/	23 cm							
			5	SS	78/	23 cm							
			6	SS	72/	23 cm							
	Grey Reddish Green		7	SS	100/	8 cm							
107.2			8	SS	100/	15 cm							
6.2	Weathered Sound												
105.1	Bedrock (Queenston Shale)		9	BXL RC	REC 97%								RQD 73%
8.3	End of Borehole * Water Level not Encountered												

FOUNDATION INVESTIGATION REPORT

37

For

Hwy. 403 - Brant St. Underpass

W.P. 199-77-13, Site 10-1337-340

District 4, Burlington

INTRODUCTION

This report summarizes the factual information obtained from a foundation investigation performed at the above-mentioned site. Fieldwork consisted of ten sampled boreholes and four dynamic cone penetration tests advanced during the period 85 01 17 to 85 01 28. Bedrock was proven by obtaining up to 3.1 m of rock core in BXL size. Boring depths ranged from 11.6 m to 16.8 m and all borings were advanced utilizing track mounted auger machines.

SITE DESCRIPTION

The site is located on existing Brant St., in the City of Burlington, Regional Municipality of Halton.

At the future crossing of Hwy. 403 at Brant St. it is proposed to construct a twin cast-in-place 4-span concrete structure which will carry Brant St. over new Hwy. 403.

Brant St. is presently a four-lane urban roadway.

At the proposed crossing, preliminary grading has been carried out along the Hwy. 403 right-of-way both to the east and west of Brant St., with the most significant cut being immediately to the west of the proposed structure.

The site is located in the physiographic region known as the South Slope which is characterized in this area by a ground moraine of limited relief.

The bedrock underlying the site is a red shale with siltstone of the Queenston Formation.

SUBSURFACE CONDITIONS

General

The boundaries of the various subsoil types are shown on the Record of Borehole Sheets located in the Appendix. The locations and elevations of the borings, along with an estimated stratigraphic profile based on the borehole data, are shown on Drawing Number 1997713-A.* This report must be read in conjunction with the above-noted items.

* DWG NO 2 OF THE CONTRACT DWG'S

The subsoil conditions are fairly uniform across the site. Underlying up to 2.7 m of silty clay, some gravel and sand fill, is a heterogeneous mixture of silty clay with varying proportions of sand and gravel, and occasional cobbles and boulders. The site is underlain by a red shale with siltstone of the Queenston Formation.

The various soil types encountered are described in the following paragraphs.

FILL - Silty Clay, some Gravel and Sand

This material was encountered at all borehole locations except numbers 7 and 8. It ranged in thickness from 1.3 m at borehole 9 to 2.7 m at borehole 1. The consistency of this deposit, as determined by Standard Penetration Test 'N' values ranged from firm to very stiff.

Heterogeneous mixture of Silty Clay, Sand and Gravel (Glacial Till)

This is the predominant soil type at the site and was encountered at all borehole locations. It consists of a heterogeneous mixture of silty clay with varying proportions of sand and gravel.

The results of Atterberg Limit and water content testing are plotted on the Plasticity Chart, Figure No. 1, and are summarized as follows:

		Range	Average
Water Content	(W)%	7-23	13
Liquid Limit	(W _L)%	20-36	26
Plastic Limit	(W _p)%	13-19	16
Plasticity Index	(I _p)%	3-18	12

The results of grain size distribution tests are plotted in envelope form on Figure 2 of the Appendix.

Standard Penetration 'N' values ranged from 16 to over 100 blows per 0.3 m penetration which indicates that the consistency of this deposit ranges from very stiff to hard. Occasional cobbles and boulders were encountered throughout the deposit.

Bedrock

Bedrock was proven by obtaining up to 3.1 m of rock core in BXL size. The bedrock was encountered at depths ranging from 11.5 m to 13.8 m.

The bedrock at this site is from the Queenston Formation and consists of red shales with interbedded siltstone. The upper 1 m to 2 m of the shale is in a highly weathered condition with alternating layers of broken rock and a red silty clay material.

A detailed description of the rock cores was prepared by Mr. E. Magni, Ministry of Transportation and Communications, Geologist and his report is located in the Appendix.

Groundwater

The groundwater was found at various elevations across the site. However, the true groundwater elevation is believed to be controlled by the Highway 403 advance cut just to the southwest of the site and is assumed to be at or below elevation 122 + m.

MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of Messrs. R. Thomas and D. Graham, Student Specialist Engineers utilizing equipment owned and operated by Atcost Soil Drilling, Concord and Dominion Soil Investigation Ltd., Scarborough. This report was written by Mr. B. Ruck, Project Foundations Engineer and reviewed by Mr. K. Selby, Chief Foundations Engineer, (West).



P. Payer
P. Payer, P. Eng.
Sr. Foundation Engineer

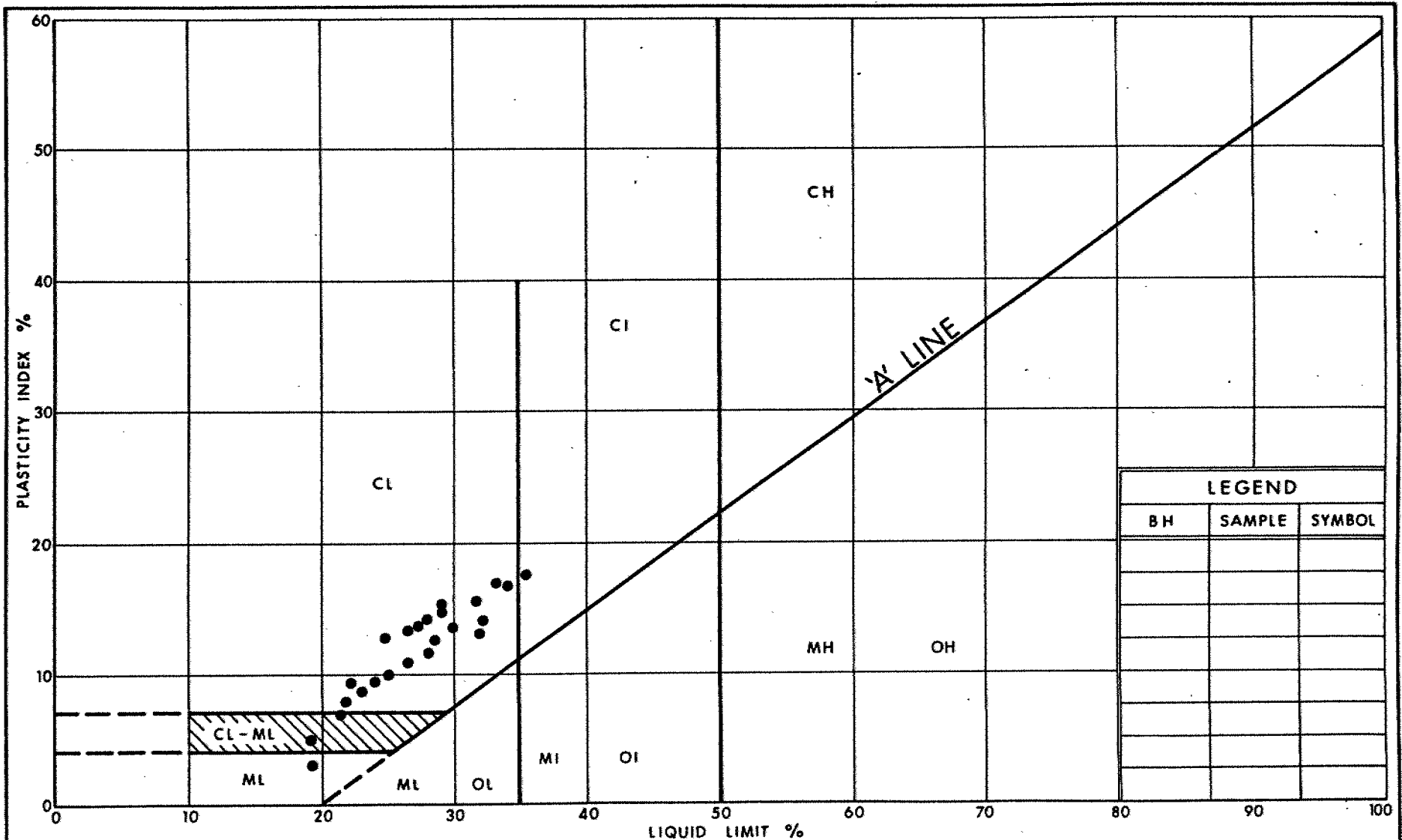
M. Devata
M. Devata, P. Eng.
Chief Foundation Engineer

APPENDIX

DESCRIPTION OF ROCK CORE - W.P. 199-77-13

BOREHOLE NUMBER				CORE DESCRIPTION	
	DEPTH (m)	% CR*	% RQD*	DEPTH (m)	DESCRIPTION
2	12.31-13.90	85	66	12.31-12.80	Shale (100%), red, moderately weathered, very closely spaced joints
				12.80-12.90	Shale (75%), red, unweathered, medium spaced joints, with siltstone (25%), green, unweathered
4	13.59-15.19 15.19-16.71	97 100	57 100	13.59-13.74	Shale (100%), red, moderately weathered, very closely spaced joints
				13.74-16.71	Shale (80%), red, unweathered, medium spaced joints, with siltstone (20%), green, unweathered, with moderately weathered layer of red shale from 14.05 m - 14.20 m
7	13.64-15.19 15.19-16.71	92 100	73 58	13.64-15.19	Shale (90%), red, unweathered, medium spaced joints, with siltstone (10%), green, unweathered
8	13.56-15.18	100	79	13.64-15.19	Shale (75%), red, unweathered, medium spaced joints, with siltstone (25%), green, unweathered
9	15.19-16.76	90	48	15.19-16.76	Shale (90%), red, unweathered, medium spaced joints, with siltstone (10%), green, unweathered

* CR = CORE RECOVERY ; RQD = ROCK QUALITY DESIGNATION



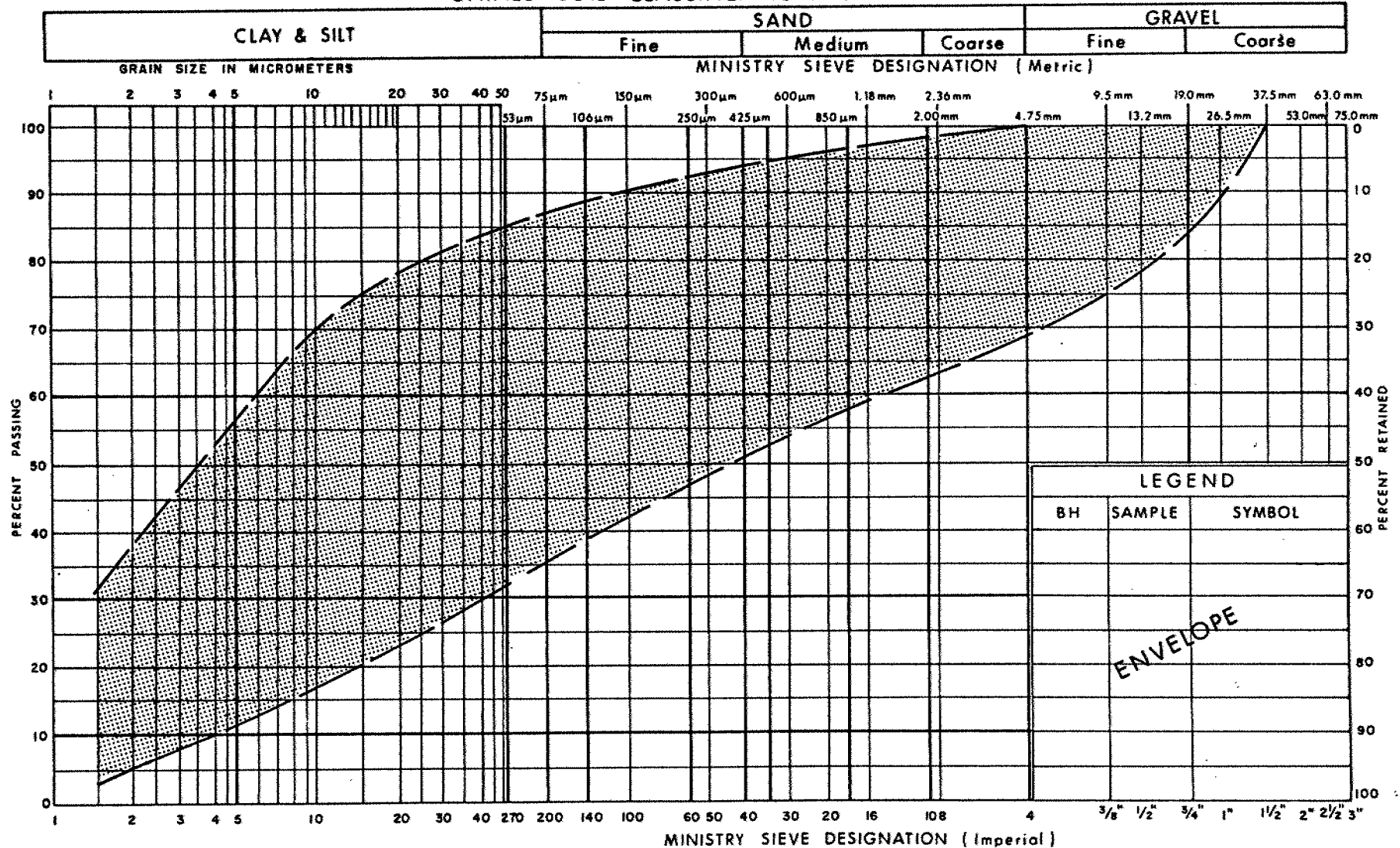
Ministry of
Transportation and
Communications

PLASTICITY CHART
HETEROGENEOUS MIXTURE OF SILTY CLAY, SAND & GRAVEL
 (Glacial Till)

FIG No 1

W P 199 - 77 - 13

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION
HETEROGENEOUS MIXTURE OF SILTY CLAY, SAND & GRAVEL
 (Glacial Till)

FIG No 2

W P 199-77-13

RECORD OF BOREHOLE No 1

METRIC

W P 199-77-13 LOCATION Co-ords. N 4 800 814.5; E 277 884.0 ORIGINATED BY BR
DIST 4 HWY 403 BOREHOLE TYPE Hollow Stem Auger COMPILED BY BR
DATUM Geodetic DATE 85 01 17 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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					
130.2	Ground Surface													
0.0	Silty Clay Some Gravel and Sand Fill Stiff		1	SS	11									21 41 26 11
			2	SS	15									
127.5			3	SS	15									
2.7			4	SS	34									
	Heterogeneous Mixture of Silty Clay, Sand and Gravel Hard Glacial Till occasional cobbles and boulders		5	SS	40									
			6	SS	70									
			7	SS	33									
			8	SS	49									
			9	SS	99									
			10	SS	100									25 26 38 11
118.3														
11.9	Bedrock Weathered Queenston Shale		11	SS	100/6 cm									
116.7			12	SS	100/5 cm									
13.5	End of Borehole													

+3, x⁵: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 2

METRIC

W P 199-77-13 LOCATION Co-ords. N 4 800 795.0; E 277 903.0 ORIGINATED BY BR
 DIST 4 HWY 403 BOREHOLE TYPE Hollow Stem Auger - BXL Rock Coring COMPILED BY BR
 DATUM Geodetic DATE 85-01-18 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					
129.9	Ground Surface																
0.0	Silty Clay some sand and gravel Fill Stiff		1	SS	11		128										
121.5			2	SS	72		126										
2.4	Heterogeneous Mixture of Silty Clay Sand and Gravel Hard Glacial Till Occasional cobbles and boulders		3	SS	69		124										
			4	SS	35		122										
			5	SS	44		120										
			6	SS	100	28 cm											
			7	SS	100	25 cm											
118.3			8	SS	100	10 cm	118										
11.6	Bedrock Weathered Sound Queenston Shale		9	BXL RC	REC 85%		116										RQD = 66%
116.0	End of Borehole * Water Level Not Observed																
13.9																	



RECORD OF BOREHOLE No 3

METRIC

W P 199-77-13 LOCATION Co-ords. N 4 800 770.0; E 277 927.5
DIST 4 HWY 403 BOREHOLE TYPE Solid Stem Auger
DATUM Geodetic DATE 85 01 21
ORIGINATED BY RT
COMPILED BY BR
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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20	40	60	80	100					
129.3	Ground Surface															
0.0	Silty Clay some sand and gravel Fill		1	SS	16											
126.9	Stiff to Very Stiff															
2.4	Heterogeneous Mixture of Silty Clay Sand and Gravel		2	SS	38											
	Hard		3	SS	70											
	Glacial Till		4	SS	45											
	Occasional cobbles and boulders		5	SS	44											
			6	SS	100/23 cm											
			7	SS	100/30 cm											
117.8	Bedrock															
117.1	Weathered															
12.2	End of Borehole															
	* Water Level Not Observed															

+3, x5: Numbers refer to
Sensitivity

20
15 + 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 5

METRIC

W P 199-77-13 LOCATION Co-ords. N 4 800 720.0; E 277 977.0 ORIGINATED BY RT
DIST 4 HWY 403 BOREHOLE TYPE Solid Stem Auger COMPILED BY BR
DATUM Geodetic DATE 85 01 21 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					
127.6	Ground Surface															
0.0	Silty Clay some sand and gravel Fill		1	SS	16											
125.4	Very Stiff		2	SS	27											
2.2			3	SS	54											
			4	SS	55											
	Heterogeneous Mixture of Silty Clay Sand and Gravel		5	SS	61											
			6	SS	41											
	Very Stiff to Hard		7	SS	19											
	Glacial Till															
	Occasional cobbles and boulders		8	SS	43											
			9	SS	100/18 cm											
			10	SS	100/23 cm											
115.8																
11.8	Bedrock Weathered Queenston Shale		11	SS	100/0 cm											
113.9			12	AS												
13.7	End of Borehole															
	* Water Level Observed 2 hours after completion															

+3, x5: Numbers refer to
Sensitivity

20
15 \div 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 6

METRIC

W P 199-77-13 LOCATION Co-ords. N 4800 693.0; E 277 963.5 ORIGINATED BY DG
 DIST 4 HWY 403 BOREHOLE TYPE Solid Stem Auger COMPILED BY BR
 DATUM Geodetic DATE 85 01 25 CHECKED BY LD

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	50 100 150 200 250					
128.1	Ground Surface													
0.0	Silty Clay some sand and gravel Fill		1	SS	16									
126.4	Very Stiff		2	SS	37									
1.7			3	SS	44									
			4	SS	25									
	Heterogeneous Mixture of Silty Clay Sand and Gravel		5	SS	30									
	Very Stiff to Hard		6	SS	16									
	Glacial Till		7	SS	19									
			8	SS	33									
			9	SS	100/30 cm									
			10	SS	79/23 cm									
116.4	Bedrock - Weathered		11	SS	100/5 cm									
115.9														
12.2	End of Borehole													
	* Water Level Not Observed													

*3, *5: Numbers refer to
Sensitivity

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



RECORD OF BOREHOLE No 7

METRIC

W P 199-77-13 LOCATION Co-ords. N 4 800 708.5; E 277 941.5 ORIGINATED BY RT
DIST 4 HWY 403 BOREHOLE TYPE Solid Stem Auger & BXL Rock Coring COMPILED BY BR
DATUM Geodetic DATE 85 01 28 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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
129.0	Ground Surface																
0.0	Heterogeneous Mixture of Silty Clay Sand and Gravel Very Stiff to Hard Glacial Till		1	SS	50		128										
			2	SS	55		126										
			3	SS	37		124										
			4	SS	27		122										
			5	SS	39		120										
			6	SS	1007	25 cm	118										
			7	SS	1007	23 cm	116										
			8	SS	1007	23 cm	114										
116.5	Bedrock		9	BXL RC	REC 92%		112										
12.5	Weathered Sound		10	BXL RC	REC 100%												
	Queenston Shale																
112.3	End of Borehole																
16.7																	

+3, x5: Numbers refer to
Sensitivity

20
15 \div 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 9										METRIC				
W P 199-77-13		LOCATION Co-ords. N 4 800 759.0; E 277 892.0		ORIGINATED BY RT										
DIST 4 HWY 403		BOREHOLE TYPE Solid Stem Auger & BXL Rock Coring		COMPILED BY BR										
DATUM Geodetic		DATE 85 01 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					
130.4	Ground Surface													
0.0	Silty Clay													
129.1	some sand and gravel		1	SS	21									
1.3	Fill - Very Stiff		2	SS	47									
			3	SS	66									
	Heterogeneous Mixture of Silty Clay Sand and Gravel		4	SS	27									
	Very Stiff to Hard		5	SS	37									
	Glacial Till		6	SS	37									
	Occasional cobbles and boulders		7	SS	65									
			8	SS	100									
			9	SS	100	28 cm								
117.4			10	SS	100	8 cm								
13.0	Bedrock													
	Weathered Sound													
	Queenston Shale		11	BXL RC	REC 90%									RQD = 48%
113.6														
16.8	End of Borehole													
	* Water Level Upon Completion													

RECORD OF BOREHOLE No 10

METRIC

W P 199-77-13 LOCATION Co-ords. N 4 800 780.5; E 277 871.5 ORIGINATED BY RT
DIST 4 HWY 403 BOREHOLE TYPE Solid Stem Auger COMPILED BY BR
DATUM Geodetic DATE 85 01 23 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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					
130.3	Ground Surface													
0.0	Silty Clay some sand and gravel Fill Firm		1	SS	9		130							
128.2			2	SS	8		128							
2.1			3	SS	42									
			4	SS	51									
			5	SS	37									
			6	SS	40									
			7	SS	23									
			8	SS	51									
			9	SS	100/	28 cm								
			10	SS	100/	15 cm								
			11	SS	100/	15 cm								
			12	SS	100/	8 cm								
116.5														
13.8	End of Borehole						116							
	* Water Level 2 hours after Completion													

OFFICE REPORT ON SOIL EXPLORATION

*3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10



Golder Associates

CONSULTING GEOTECHNICAL AND MINING ENGINEERS



REPORT
TO

MINISTRY OF TRANSPORTATION
AND COMMUNICATIONS

FOUNDATION INVESTIGATION
PROPOSED OVERPASS BRIDGES AT Q.E.W./
HWY. 403

W.P. 83-74-28 } SITE 10-32A
W.P. 83-74-29 } DISTRICT 4
CONT 91-22

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January, 1981

801-1341

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ABSTRACT

A subsurface investigation was carried out by Golder Associates for the Ministry of Transportation and Communications at the site of two proposed overpass bridges on the QEW/403 Interchange in Burlington, Ontario.

In summary, the borings indicate that stiff to hard clayey silt fill overlies a hard clayey to sandy silt (residual soil) stratum which overlies Queenston shale bedrock at depths between 1.5 and 2.3 m below existing ground surface. The shale bedrock is highly weathered for the top two metres. Groundwater levels measured during the investigation were at or just above the fill/residual soil contact and generally follow the surface topography.

The proposed structures may be founded in the natural soil or in competent bedrock. Perched abutments placed within the embankment fill may be adopted. Depending on the tolerance of the proposed structures to differential settlement these abutments may be placed directly on specially prepared fill or founded on piles driven through the embankment and bearing on bedrock.

1.0 INTRODUCTION

Golder Associates have been retained by the Ministry of Transportation and Communications (letter dated December 5, 1980) to carry out a foundation investigation for two proposed overpass bridges on the QEW/403 Interchange in Burlington, Ontario (overall W.P. 837407).

The purpose of the investigation was to determine the subsurface conditions at the site and based on these data, to provide engineering recommendations for the geotechnical design of the foundations for the proposed structures.

The investigation was carried out, and this report was prepared, in accordance with Golder Associates' letter, dated December 23, 1980.

2.0 DESCRIPTION OF PROJECT

Details of the project were provided during a meeting between Mr. Selby of the Ministry of Transportation and Communications, and Messrs. Davis and Busbridge of Golder Associates on December 15, 1980. Additional details were provided on two plans titled "Bridge Site, Proposed Northbound QEW Underpass at Ramp QEW-S to Hwy. 403" designated Site 10-320, W.P. 837428-A, dated September 30, 1980, and "Bridge Site, Proposed Southbound QEW Underpass at Ramp QEW-S to Hwy. 403" designated Site 10-321, W.P. 837429-A, dated October 1, 1980, and in an M.T.C. memorandum dated October 27, 1980. It is understood that the above mentioned projects form part of overall W.P. 837407.

It is understood that at Site 10-320, the proposed bridge will be a four span post-tensioned type with spans of approximately 22 m, 45 m, 39 m and 22 m. It will allow for QEW northbound traffic to proceed westerly along Hwy. 403. The centre column is to be located at the median of the future QEW.

At Site 10-321 it is understood that the proposed bridge will be a three span post-tensioned type with spans of approximately 20 m, 40 m and 20 m. It will allow for traffic carried by the previous bridge deck to overpass the future QEW southbound lanes and proceed westerly along Hwy. 403.

The approximate locations of the footings were shown in red on the two plans provided, along with profiles of both QEW and the ramps under consideration in this area.

3.0 SITE AND GEOLOGY

The proposed bridges are to be located along the QEW, south of the North Service Road and west of Brant Street in the City of Burlington, Ontario. The topography at the site is generally flat lying having an elevation about 106 m (Geodetic). Immediately to the north of the site the land rises towards the Niagara Escarpment.

The site is located in the physiographic region known as the Iroquois Plain, consisting of a narrow strip of land along the shores of the present Lake Ontario. This level plain was formed by post-glacial Lake Iroquois which then occupied the Lake Ontario basin. In the Burlington area the surficial soils in this plain consist of beach sands, clayey silt till and/or residual red clayey silt derived from weathering of the underlying Queenston shale bedrock. The Queenston shale formation consists of thinly bedded red clay shale with occasional bands of grey limestone.

4.0 INVESTIGATION PROCEDURE

The field work for this investigation was carried out between December 22 and 31, 1980. The elevations of the boreholes were determined on January 5, 1981. During this time nine boreholes were put down at the two sites (Drawings 837428-A and 837429-A) using a Type 5.3.i drillrig supplied and operated by Master Soil Investigations Ltd., of Toronto, a specialist drilling contractor. Within the overburden soils the boreholes were advanced with solid stem augers. In each

boring, standard penetration tests were carried out at 0.76 m intervals of depth, and samples were obtained using a standard 50 mm O.D. split spoon sampler, which was advanced by a 63.5 kg mass falling freely for 0.76 m. In each boring, bedrock was cored for depths of between 2.8 m to 3.8 m in BXL size. Details of the drilling and sampling operations are summarized on the Record of Borehole sheets. A filtered standpipe was sealed into each boring to allow monitoring of the groundwater level.

The field work was supervised throughout by a member of Golder Associates' engineering staff, who located the borings in the field, cleared underground services, directed the drilling and sampling operations, logged the borings and cared for the samples. The borehole locations were established by tape measurement. The ground surface elevations at each boring was determined relative to an M.T.C. survey monument (Drawing 837428-A). The elevation of this control point was provided by a member from the M.T.C. staff on January 8, 1981. It is understood that all ground surface elevations are referred to Geodetic datum.

Following field identification and logging, all the samples obtained during the investigation were placed in air-tight containers and brought to our laboratory where they were examined in detail. Representative samples of the soil were tested to determine their index properties.

5.0 SUBSURFACE CONDITIONS

The detailed stratigraphy encountered in each of the boreholes together with the results of laboratory tests carried out on representative samples of the soil strata are given on the attached Record of Borehole sheets and on Figures 1 to 3. The locations of the boreholes and the simplified stratigraphy at the boreholes are shown on Drawings 837428-A and 837429-A. It should be noted that the stratigraphic boundaries indicated on the borehole logs and longitudinal sections are inferred from a transition from one soil type

to another and do not necessarily indicate an exact plane of geologic change. Further, the subsurface conditions may vary between boreholes.

5.1 Site 10-320

At the locations of Boreholes 5, 6 and 8, up to 0.3 m of topsoil was encountered at ground surface. A layer of granular material comprising crushed stone (sand and gravel sizes) was encountered at Borehole 7 and extends to a depth of 1.4 m (Elev. 104.8 m). This material forms part of the shoulder of the existing Highway 403 exit ramp to the QEW. The topsoil at Boreholes 5, 6 and 8, the granular fill at Borehole 7 as well as ground surface at Borehole 9 are underlain by a layer of clayey silt containing some sand and gravel, pieces of red brick and occasional thin lenses of black organic matter. This fill varies in thickness from 0.6 m at Boreholes 5 to 2.0 m at Borehole 7. The fill is underlain by hard (N* values greater than 30) clayey silt containing a trace of sand and gravel to sandy silt containing some gravel, with red shale fragments throughout.

The clayey silt material has a grain size distribution (Figures 1 and 2) similar to that of a glacial till. However, the coarser fraction of the soil is angular and easily friable. This material has the characteristics of a residual soil (soil material with the original texture, structure and mineralogy of the rock completely destroyed) rather than the matrix of a glacial till. It extends to a depth of about 2.3 m (between Elev. 100.1 m to 103.2 m) below ground surface except at Borehole 7 where it extends to 4.4 m (Elev. 101.8 m) below ground surface. The fill has a grain size distribution similar to that of the residual soil (Figure 1 - BH7, SA 3) and is probably local material placed during previous construction activities.

The water content of the sandy silt is about 10 per cent and that of the clayey silt is about 17 per cent. Both

*N - Standard Penetration Resistance - See Explanation of Terms, Appendix A.

materials (forming the residual soil) exhibit low plasticities with liquid limits between 16 to 22 per cent and a plasticity index of about 2 (Figure 3). The residual soil encountered at Boreholes 5 and 9 is more granular (Figure 2) than that of Boreholes 6, 7 and 8, possibly due to it containing more weathered shale fragments. This material is underlain by highly weathered to faintly weathered, reddish brown, weak to strong Queenston shale. The shale is irregularly banded with grey limestone layers about 80 mm in thickness and an occasional thin seam of red clay. The core recovery was generally in excess of 70 per cent and the Rock Quality Designations (RQD) lies between zero and 80 per cent, the higher quality being recorded for core recovered about 2 m below the overburden/bedrock interface.

As is evidenced from the profile shown on Drawing 837428-A ground surface and the various stratigraphic units slope gently from north (BH 5) to south (BH 9). The top surface of the residual soil also slopes towards the south but is more erratic due to the surface having been changed by previous construction activities and fill placement. The elevation of Borehole 7 is higher than the other boreholes in the same general area due to it being located near the southern shoulder of the exit ramp from Hwy. 403.

The groundwater surface measured in the standpipes also slopes towards the south generally following the ground surface topography.

5.2 Site 10-321

At the location of Boreholes 1 to 4 the ground surface is underlain by between 0.12 and 0.36 m of topsoil. At Boreholes 3 and 4, the topsoil overlies a layer of fill composed of clayey silt containing some sand and gravel, pieces of red brick and occasional thin lenses of black organic matter. The fill extends to a depth of 1.1 and 0.5 m (Elev. 104.9 and 105.1 m) below ground surface at the location of these two boreholes. The topsoil at Boreholes 1 and 2 and the fill at

Boreholes 3 and 4 is underlain by between 0.7 and 1.6 m of stiff to hard (N values 17 to 39) reddish brown clayey silt containing a trace of sand and gravel and numerous red shale fragments, and is considered to be residual soil. The residual soil was penetrated to about 1.5 to 1.8 m (Elev. 103.8 to 104.7 m) below ground surface at which depths refusal to augering was encountered. The higher 'N' values given on the Record of Borehole sheets and on the profile shown on Drawing 837429-A were obtained at the overburden/bedrock contact.

The water content of the residual soil lies between 11 and 16 per cent which is below the plastic limit of the material and indicative of a heavily overconsolidated soil. The material exhibits low plasticity with a plasticity index of about 10 (Figure 3).

Bedrock was extracted by BXL rock coring techniques. The bedrock was found to be a highly weathered to faintly weathered at depth, reddish brown, weak to strong at depth, Queenston shale. The shale is irregularly banded with grey limestone layers about 80 mm in thickness and is occasionally intercepted by thin seams of red clay. The core recovery was about 73 per cent and the RQD was between zero and 60 per cent and generally below 50 per cent. This indicates that the shale bedrock is of generally poor to fair quality.

The groundwater level measured within the standpipes slopes towards the south, generally following the surface topography. Although the water level is indicated as being higher at Borehole 3 than at Borehole 2 this may be due to an interceptor ditch located near Borehole 2 thereby depressing the water level in this area.

6.0 DISCUSSION AND RECOMMENDATIONS

The recommendations for the geotechnical aspects of design of the proposed structures, together with the comments on the construction aspects of the work contained

in this section of the report are for the guidance of the design engineer only. Contractors bidding on or undertaking the works should make their own interpretation of the factual information provided as it affects their proposed construction methods, equipment selection, scheduling and the like.

6.1 Bridge Foundations

The natural soils and rock found at the site are suitable for the support of approach embankments and bridge foundations. Depending on the most economical proportioning of footing dimensions and excavation requirements, together with the tolerance of the proposed structure to differential settlement, various options may be considered.

6.1.1 Bearing Pressure - Site 10-320

At Site 10-320 the bridge may be founded on shallow spread footings placed in the hard natural residual soil and/or weathered shale. An allowable bearing pressure of 320 kPa may be used for the design of footings placed at least 2 m into the natural residual soil and/or weathered shale bedrock which underlie the site between elevation 102.3 m (BH 5) and 99.4 m (BH9).

As an alternative to founding the proposed structure in the residual soil and/or weathered shale, consideration should be given to carrying the footings to competent shale bedrock which should be encountered about 2 m below the surface of the shale, that is, at approximately between elevations 101.6 m (BH 6) and elevation 99.1 m (BH 9). An allowable bearing pressure of 640 kPa may be used for design of footings placed in the more competent shale.

6.1.2 Bearing Pressures - Site 10-321

The bridge structure at this site may be founded on shallow spread footings founded at least 2 m into the hard natural residual soil and/or weathered shale which underlies

the site. An allowable bearing pressure of 320 kPa may be used for the design of footings placed at least 2 m into the natural residual soil and/or weathered shale bedrock.

As an alternative to founding the proposed structure in the residual soil and/or weathered shale, the footings may be founded on competent shale bedrock which should generally be encountered at about elevation 103 m. An allowable bearing pressure of 640 kPa may be used for design of footings placed in competent shale. It should be stressed that at the location of BH 1 the highly weathered shale bedrock extends down to at least elevation 101.7 m and was not penetrated. Footings extending to competent shale bedrock will have to be founded at a lower elevation in this area.

6.2 Special Considerations for Abutments

Consideration should be given to the effect of high (up to 10 m) approach embankment on the settlement of bridge abutments. The embankment loads are apt to induce settlement of the underlying soils which in turn drags down the abutments. Since the bridge piers are not subjected to the same loading, the settlements are largely differential.

6.2.1 Abutments on Spread Footings

Where abutments are placed on the residual soil or highly weathered shale bedrock it is anticipated that a differential settlement of up to 50 mm could develop between the abutment and the adjacent bridge pier. This can be reduced to less than 25 mm by ensuring that footings are taken down to the competent shale as discussed in 6.1.1 and 6.1.2.

Where the abutments are required to act as retaining walls the lateral earth loads will depend on the type and method of placement of the fill materials. The following recommendations are made in respect to the design of the

abutment retaining walls:

- (i) Selected granular fill, such as M.T.C. Granular 'B' should be used as backfill immediately behind the structures. The granular fill should be placed in the wedge-shaped zone defined by a 45 degree line extending up and back from the rear face of the structures' footings;
- (ii) All granular fill should be compacted in 200 mm thick lifts to 95 per cent of the standard Proctor dry density of the material. However, heavy compaction equipment should not be used behind any structure within a lateral distance equal to the current height of the fill above the base of the structure;
- (iii) Provided that the above criteria are satisfied, a coefficient of active earth pressure (K_a) of 0.3 may be used in computing lateral earth pressures, if an outward deflection of approximately 1/2 per cent of the wall height can be tolerated at the bridge bearings. If this amount of deflection cannot be absorbed, than an at-rest coefficient of earth pressure (K_o) equal to 0.5, should be used in calculating the lateral earth pressures. A coefficient of friction less than or equal to 0.55 may be assumed between the concrete footings and the bedrock. A bulk unit weight of 20 kN/m^3 may be assumed for the Granular 'B' backfill;
- (iv) An adequate drainage system should be provided behind the abutments to prevent build-up of hydrostatic forces. The drainage system should include a properly designed filter to prevent clogging of the pipes. Provision should be made to allow cleaning or rodding of the pipes, should they become clogged.

6.2.2 Perched Abutments

As an alternative to abutments on spread footings consideration could be given to adopting perched abutments placed within the embankment fill. Depending on the degree of continuity of the bridge deck structure and therefore its tolerance to differential settlement these abutments can be supported on specially prepared embankment material or on piles driven through the embankment fill.

Where no piling is used it will be necessary to remove all existing fill and to replace with granular fill, compacted to a minimum of 100 per cent of the Standard Proctor density. The granular material should extend from the underside of the abutment down to the natural soil at a slope of 2 horizontal to 1 vertical. Material within 1.5 m of the underside of the abutment should conform to M.T.C Granular 'B' specification. An allowable bearing pressure of 200 kPa may be used for the design of the abutment footing provided it is placed a minimum of 3 m from the face of the slope measured at the founding level. Where the bridge structure cannot tolerate a differential settlement of 75 mm between abutment and pier it is recommended that perched abutments are founded on piles driven through the embankment fill.

The piles should be founded on the shale bedrock. Steel H-pile section HP310 x 79 driven to a set of 20 blows/25 mm using a driving energy of at least 54 kilo joules per blow will be capable of supporting a working load of 700 kN per pile.

6.3 General Considerations

All footings should be placed a minimum 1.2 m below final exterior grade for frost protection.

To ensure that the footings are placed on relatively undisturbed natural residual soil, weathered shale or

competent bedrock, it is recommended that the base of all footing excavations be inspected by a qualified geotechnical engineer prior to placement of any concrete.

6.4 Comments on Construction

It is anticipated that it will be possible to excavate the top 4 m of shale by ripping although progress may be slow where bands of limestone are encountered. The ingress of water into the excavations must be prevented as water will soften the shale. Further, the foundations should not be exposed any more than necessary and should not be left open overnight. A coating of working concrete should be applied to the foundation surface as soon as possible after excavation.

In order to allow construction of footings placed below the groundwater level, suitable shoring of the excavations will be required. The control of groundwater inflow by methods such as pumping from sumps will also be required.

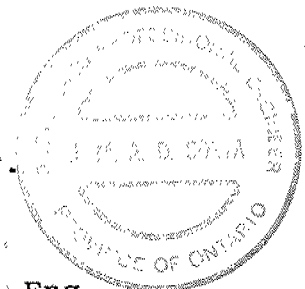
GOLDER ASSOCIATES

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801-1341

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/0.3m)	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

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

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 = $\frac{c_u}{\tau_r}$

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

W P 837429-A LOCATION Co-ords 4,799,746N; 278,076 E (STA 8+ 921) ORIGINATED BY A.H.T.
DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.H.C.
DATUM Geodetic DATE December 22, 1980 CHECKED BY J.S.C.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
106.24	Ground Level																
0.00																	
105.88	Topsoil																
0.36	Clayey Silt with shale fragments (Residual soil). Hard.		1	SS	39												0 6 70 24
104.72	Red and Greenish Grey.		2	SS	50/127 mm												
1.52	Shale Bedrock. Highly weathered reddish brown, fine grained, weak, irregularly ban- ded with grey lime- stone layers about 80mm thick. 76mm clay seam at Elev. 103.3 m.		3	R.C. BXL	95%												RQD 31%
			4	RC BXL	89%												RQD 9%
101.70																	
4.54	End of Borehole.																W.L. elev 105.17 on Jan.5, 1981

RECORD OF BOREHOLE No. 2

W P 837429-A LOCATION Co-ords 4,799,727 N; 278,084 E (STA 8+942.5) ORIGINATED BY A.H.T.
DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
DATUM Geodetic DATE December 23, 1980 CHECKED BY J. Smith

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
106.33	Ground Level																
106.09	Topsoil						Seal 106										
0.24	Clayey Silt, some shale fragments (residual soil).		1	SS	17		Backfill										
	Very Stiff.						105										
104.50	Reddish Brown.		2	SS	25												
1.83	Shale bedrock, highly weathered, reddish brown, fine grained, weak.		3	RC BXL	91%		104										RQD 18%
103.28	32mm clay seam at Elev. 103.7 m.																
3.05	Shale Bedrock. Faintly weathered reddish brown, fine grained, strong.		4	RC BXL	100%		103										RQD 30%
	Irregularly banded with grey limestone layers about 80 mm thick.						Pea Gravel										
101.21			5	RC BXL	100%		102										RQD 42%
5.12	End of Borehole.						101										W.L. elev. 104.44 on Jan. 5/81

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No. 3

W P 837429-A LOCATION Co-ords 4,799,692 N; 278,102 E (STA 8+982.5) ORIGINATED BY A.H.T.
DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
DATUM Geodetic DATE December 23, 1980 CHECKED BY J. L. C.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
105.96	Ground Level																
0.00	Topsoil																
0.12	Clayey silt (Fill).																
	Hard. Brown to Black.																
104.89	Clayey Silt, with shale fragments (Residual Soil)		1	SS	17												
1.07	Hard. Reddish brown.		2	SS	115/279												
104.19	Shale Bedrock. Highly weathered. Reddish brown, fine grained, weak.		3	RC BXL	73%												
1.77	Shale Bedrock. Faintly weathered, reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		4	RC BXL	92%												
103.16			5	RC BXL	100%												
2.80																	
101.33																	
4.63	End of Borehole.																

RECORD OF BOREHOLE No.4

W P 837429-A LOCATION Co-ords 4,789,673 N; 278,111 E (STA 9+002.5) ORIGINATED BY A.H.T.
DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
DATUM Geodetic DATE December 23 & 24, 1980 CHECKED BY J. G. F.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
105.56	Ground Level																
0.00	Topsoil																
0.12	Clayey Silt (Fill).																
105.10	Stiff, Brown.																
0.46	Clayey Silt, some gravel and shale fragments (Residual Soil).		1	SS	23		105										3 13 73 11
103.79	Hard, Reddish Brown.		2	SS	84		104										RQD 53%
1.77	Shale Bedrock.			Rc													
103.33	Moderately Weathered.		3	BXL	98%		103										RQD 33%
2.23	Shale Bedrock. Faintly weathered, reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		4	BXL	97%		102										
100.96							101										Standpipe frozen at ground level on Jan. 5/81
4.60	End of Borehole.						100										

RECORD OF BOREHOLE No. 5

W P 83742B-A LOCATION Co-ords. 4,799,633 N; 278,130 E (STA 9+047) ORIGINATED BY A.H.T.
DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
DATUM Geodetic DATE December 29, 1980 CHECKED BY J. V. C.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	N' VALUES			20	40	60	80	100					
105.42	Ground Level																
0.00	Topsoil						Seal										
105.12	0.30 Clayey to Sandy Silt (Fill).		1	SS	15		105										
104.65	Stiff Red to Dark Brown		2	SS	28												
0.91	Sandy silt, some gravel, trace clay (Residual Soil).					Backfill	104										
			3	SS	76												16 34 42 8
103.27	Dense. Reddish Brown.		4	SS	55/100 mm		103										RQD 0%
2.29	Shale Bedrock. Slightly weathered. Reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		5	RC BXL	11%		102										RQD 48%
			6	RC BXL	97%		101										RQD 73%
101.29	Shale Bedrock. Faintly weathered reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		7	RC BXL	101%	Pea Gravel	100										W.L. Elev. 104.87 on Jan. 5/81
99.68	End of Borehole.						99										

RECORD OF BOREHOLE No.6

W P 837428-A LOCATION Co-ords. 4,799,610N; 278,139E (STA. 9+071) ORIGINATED BY A.H.T.
 DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
 DATUM Geodetic DATE December 29, 1980 CHECKED BY J. J. L.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
105.47	Ground Level																
0.0	Topsoil																
0.15	Clayey to Sandy Silt, some gravel (Fill).		1	SS	17	Seal	105										
			2	SS	18	Backfill	104										
103.67	Compact, Brown.		3	SS	38												
1.80	Clayey Silt, some gravel (Residual Soil).																
103.13	Hard. Reddish Brown.					Seal											
2.34	Shale Bedrock. Moderately weathered reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		4	SS	70/152	Seal	103										
			5	RC	98%		102										
101.63				BXL													
3.84	Shale Bedrock, Faintly weathered reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		6	RC	100%	Pea	101										
				BXL		Gravel											
99.80							100										
5.67	End of Borehole.						99										

RECORD OF BOREHOLE No.7

W P 837428-A LOCATION Co-ords. 4,799,575N; 278,151E (STA. 9+108) ORIGINATED BY A.H.T.
DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
DATUM Geodetic DATE December 30, 1980 CHECKED BY J.H.C.

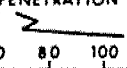
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
106.22	Ground Level																
0.0	Crushed Stone (Sand and Gravel sizes) (Fill).					Seal	106										
104.85	Very Dense, Brown.		1	SS	59		105										
1.37	Clayey Silt, some sand, trace gravel (Fill).		2	SS	44	Backfill	104										
	Stiff to Hard.		3	SS	13		103										2 20 57 21
102.84	Brown.		4	SS	40		102										
3.38	Clayey Silt, some sand, trace gravel and shale fragments (Residual Soil).		5	SS	60/152	Seal	102										
101.80	Hard. Reddish Brown.		6	SS	60/152	Seal	102										
4.42	Shale Bedrock. Highly weathered. Reddish brown. Fine grained. Weak.		7	RC	39%		101										RQD 0%
100.73			8	RC	120%		100										RQD 53%
5.49	Shale Bedrock. Moderately weathered reddish brown, fine grained, strong. Irregular banded with grey limestone layers about 80 mm thick.		9	RC	78%		99										RQD 41%
99.15			10	BXL	86%	Pea Gravel	98										RQD 86%
7.07	Shale Bedrock. Faintly weathered. Reddish brown with irregular grey limestone bands.																W.L. elev. 102.44 on Jan. 5/81
98.08	Fine grained. Strong.																
8.14	End of Borehole.																

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No.8

W P 837428-A LOCATION Co-ords. 4,799,531N; 278,161E (STA. 9+152) ORIGINATED BY A.H.T.
 DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
 DATUM Geodetic DATE December 29 & 30, 1980 CHECKED BY J.L.F.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE									
103.01	Ground Level																
0.00																	
102.70	Topsoil																
0.31	Sandy Silt to Clayey Silt (Fill). Very Stiff. Brown.																
102.06			1	SS	35		102										
0.95	Sandy Silt to Clayey Silt with gravel (Residual Soil). Hard. Reddish Brown.		2	SS	65/152	mm											
101.18																	
1.83	Shale Bedrock. Highly weathered. Reddish brown with irregular grey limestone bands about 80 mm thick. Fine grained. Weak.		3	RC BXL	44%		101									RQD 0%	
99.11			4	RC BXL	100%		100									RQD 34%	
3.90	Shale Bedrock. Slightly weathered. Reddish brown with irregular grey lime- stone bands about 80 mm thick. 75 mm clay seam at Elev. 99.1 m. Fine grained. Strong.		5	RC BXL	99%		99									RQD 45%	
			6	RC BXL	100%											RQD 100%	
97.68			7	RC BXL	100%		98									RQD 100%	
5.33	End of Borehole.						97									W.L. elev. 102.13 on Jan. 5/81	

*3, *5: Numbers refer to
Sensitivity

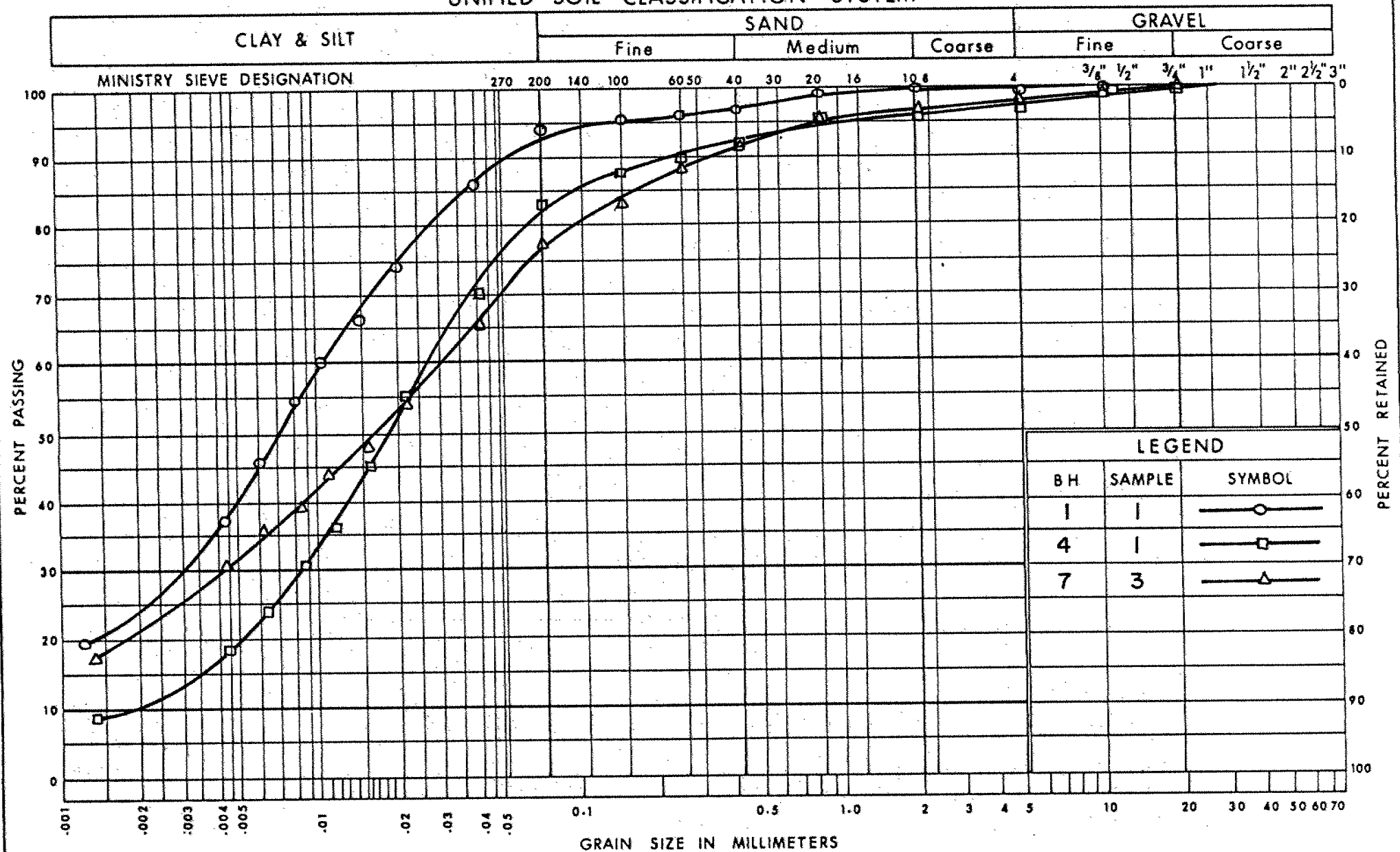
20
15 \div 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 9

W P 837428-A LOCATION Co-ords. 4,799,508N; 278,165E (STA. 9+175) ORIGINATED BY A.H.T.
 DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
 DATUM Geodetic DATE December 30 & 31, 1980 CHECKED BY g h e

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
102.44	Ground Level																
0.00	Clayey Silt to Sandy Silt, some gravel (Fill). Stiff.						Seal										
101.37	Dark brown to black, Sandy Silt, some gravel, trace clay (Residual Soil).		1	SS	19		Backfill										
1.07			2	SS	86		101										12 31 53 4
100.15	v. dense. Reddish Brown.						Seal										
2.29	Shale bedrock, slightly weathered reddish brown with grey limestone bands. Short vertical fracture at elev. 99.3 m. Fine grained. Strong.		3	SS	60/76		100										RQD 35%
			4	RC	88%												
99.09			5	RC	98%		99										RQD 50%
3.35	Shale bedrock, faintly weathered. Reddish brown with grey limestone bands about 80 mm thick. Clay seam at elev. 98.4 m. Fine grained. Strong.		6	BXL	98%		Pea Gravel										RQD 70%
96.95							97										W.L. elev. 101.74 on Jan. 5/81
5.49	End of Borehole.						96										

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

Ministry of
Transportation and
Communications

ENGINEERING SERVICES BRANCH

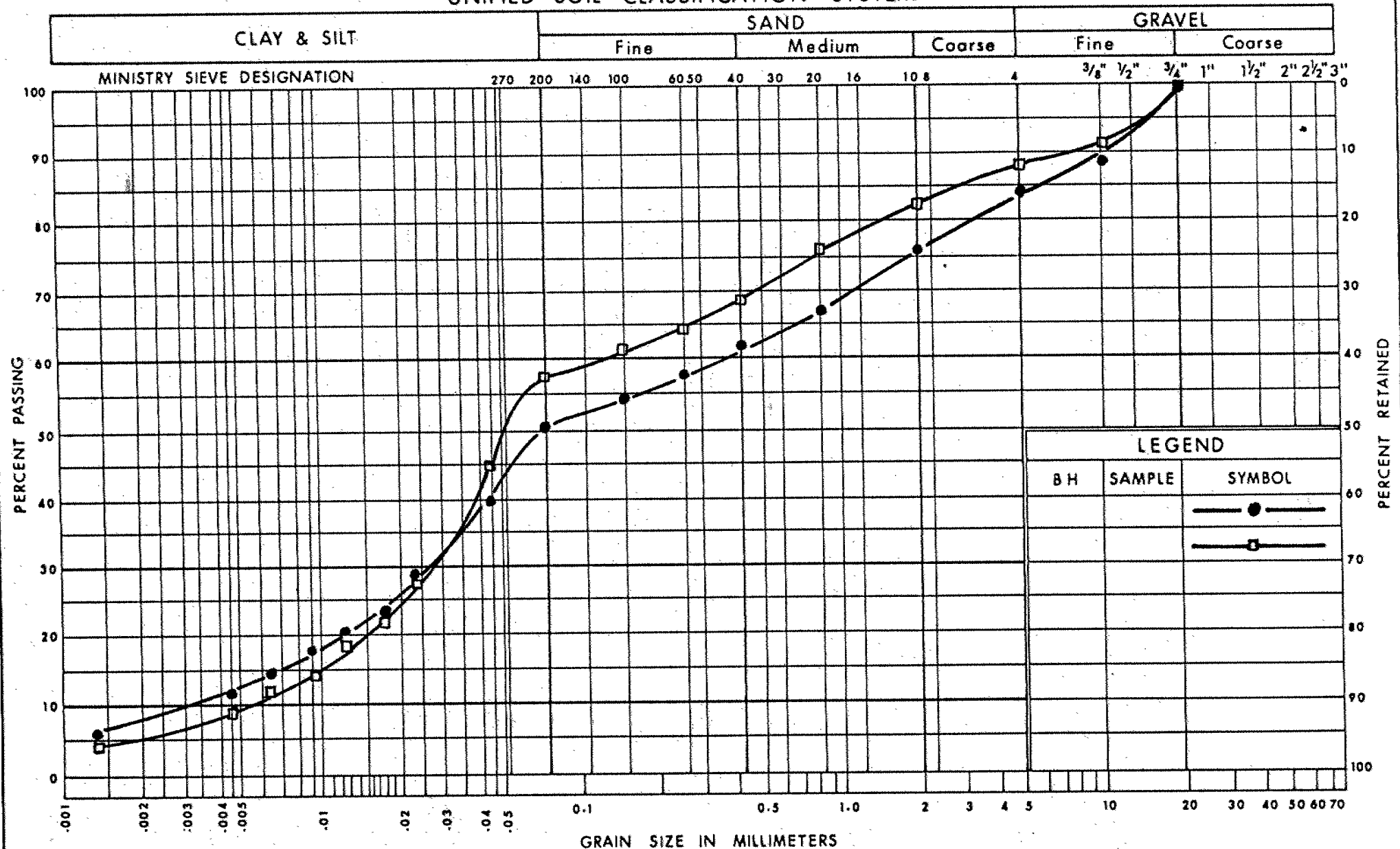
GRAIN SIZE DISTRIBUTION

CLAYEY SILT, TRACE SAND (RESIDUAL SOIL)

FIG No 1

W P 837407

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation and
Communications

Ontario

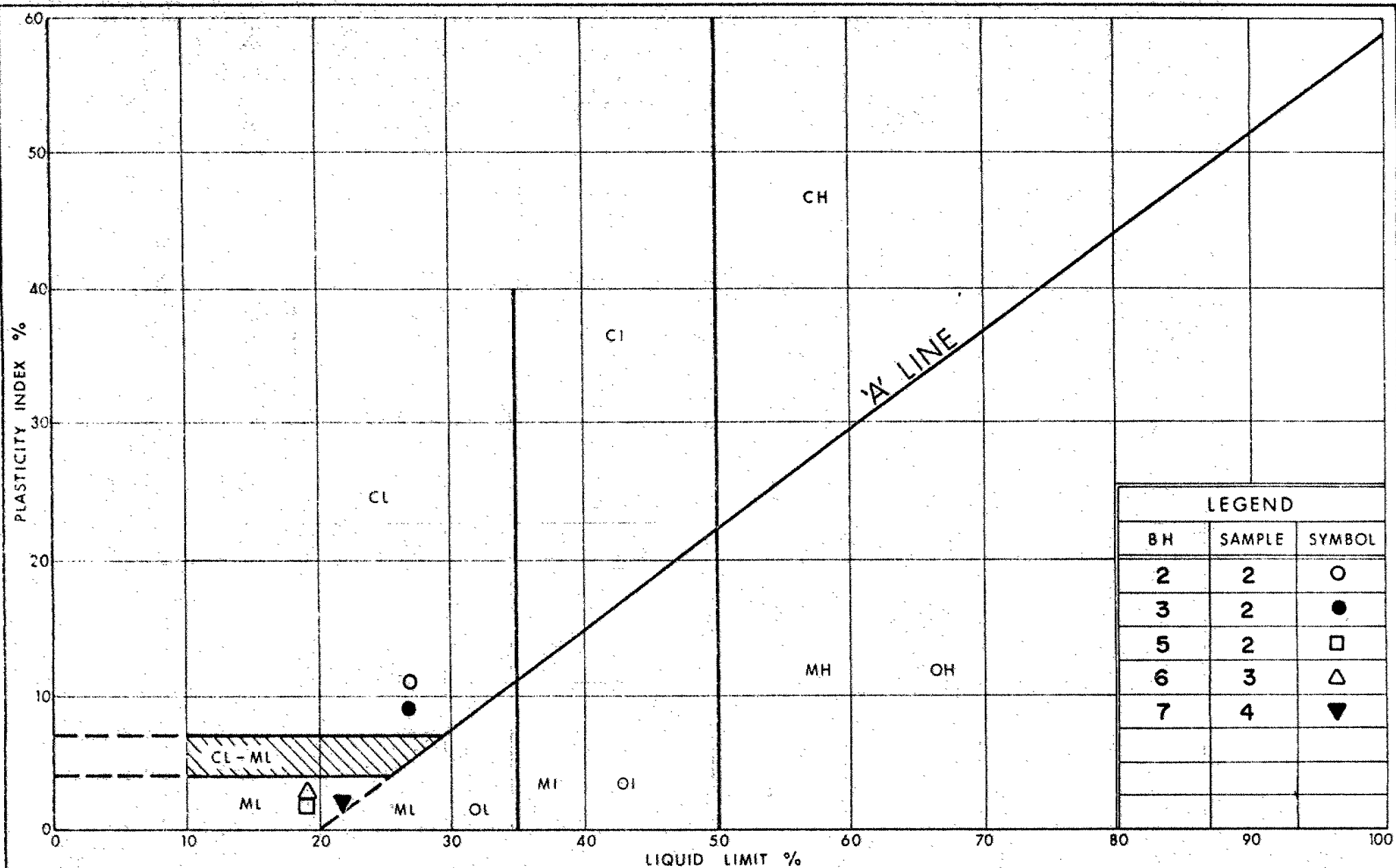
ENGINEERING SERVICES BRANCH

GRAIN SIZE DISTRIBUTION

SANDY SILT (RESIDUAL SOIL)

FIG No 2

W P 837407



Ontario

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Transportation and
Communications

PLASTICITY CHART

FIG No 3

W P 837407

OVERSIZE DRAWING

memorandum



To: Doug McDonald
Project Supervisor, Dist. 4
P.O. Box 5020, Burlington

Date: 1991 10 16

From: Foundation Design Section
Room 315, Central Building

Re: Q.E.W., S.B.L. Ramp S to Hwy. 403 U'Pass
W.P. 83-74-29, Contract No: 91-22

This memorandum hereby summarizes the discussion with Mr. Marr on 91 09 16 regarding the installation of steel H-piles at the north abutment of the above mentioned site. Apparently, one of the piles was driven approximately 0.3 m beyond the proposed tip elevation and did not achieve the recommended pile set criteria (8 blows/25 mm was measured). It is hereby confirmed that the ultimate capacity can still be produced and hence the pile is acceptable as driven, particularly in view of the fact that all other piles were successfully driven.

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

T. Sangiuliano, P. Eng.
Foundation Engineer

for

P. Payer, P. Eng.
Chief Foundation Engineer

PP/TS/jb

memorandum



To: Doug McDonald
Project Supervisor, Dist. 4
P.O. Box 5020, Burlington

Date: 1991 10 16

From: Foundation Design Section
Room 315, Central Building

Re: Q.E.W., S.B.L. Ramp S to Hwy. 403 U'Pass
W.P. 83-74-29, Contract No: 91-22

Subsequent to a request issued by the construction field staff supervising the work at the above mentioned site, the undersigned represented the Foundation Design Section in a site inspection to monitor the installation of the steel H-piles proposed at the north abutment and to establish generic pile installation criteria at the site. Installation of the three (3) innermost piles on the south row of the north abutment were monitored. The monitoring consisted of completion of pile driving records and employing the MTO Hiley Dynamic Formula at one of the piles to establish refusal criteria for the remainder of the piles. The two (2) easterly piles inspected were driven to the designed tip elevation and the third pile was driven to elevation 104.7 m or approximately 0.2 m above the designed tip elevation. In all cases, it is suspected with confidence that the piles are bearing on the bedrock and the setting criteria of 20 blows per 25 mm was satisfied. A Berminghammer B400 was used to drive the piles. Based on the observations of the pile installations witnessed, the following procedure is recommended as discussed with your field staff.

- 1) All piles shall be attempted to be driven to bedrock at the designed pile tip elevation as shown on the table given on sheet 154 of the contract documents. The measured penetration of 20 blows per 25 mm shall be confirmed at this tip elevation.
- 2) Any pile tip elevation above the proposed tip elevation can be considered acceptable provided that the 20 blows per 25 mm criteria is satisfied and the pile tip is within a "reasonable" range of the proposed tip elevation (say 0.5 metres).

If the subsurface conditions produce results beyond the limits identified above, please do not hesitate to contact this office. It is, however, suspected that no pile driving impediment is anticipated above the bedrock surface.

We trust the above assists in facilitating the pile installation at the site. If you have any queries or questions regarding the above comments, 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
for

P. Payer, P. Eng.
Chief Foundation Engineer

PP/TS/jb

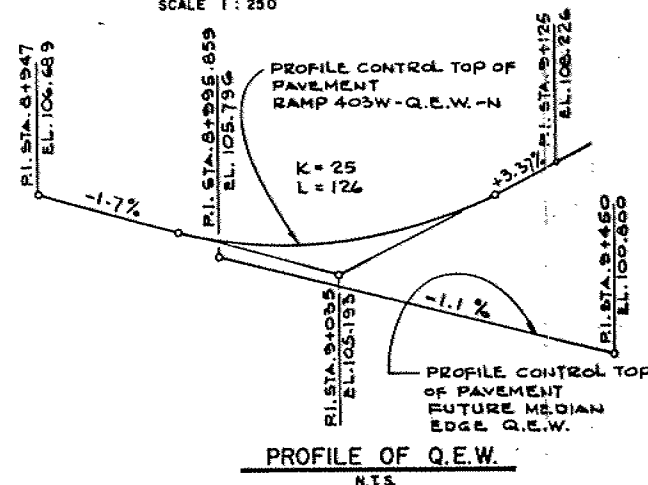
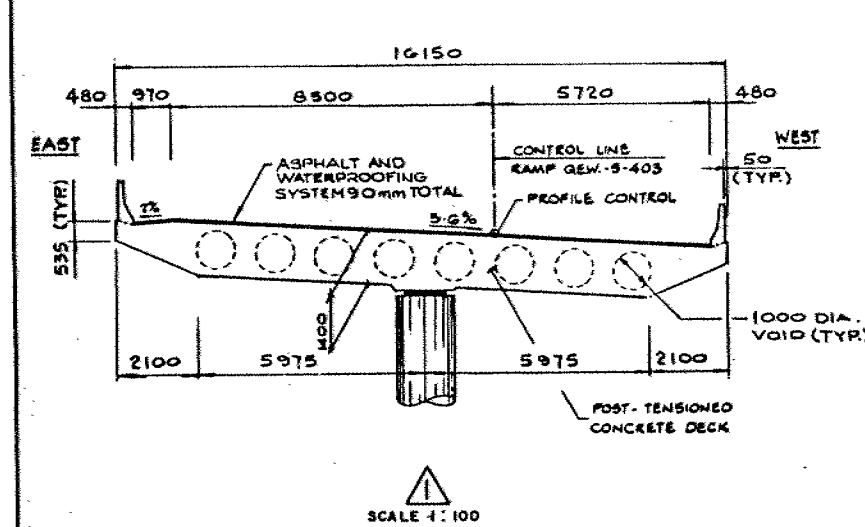
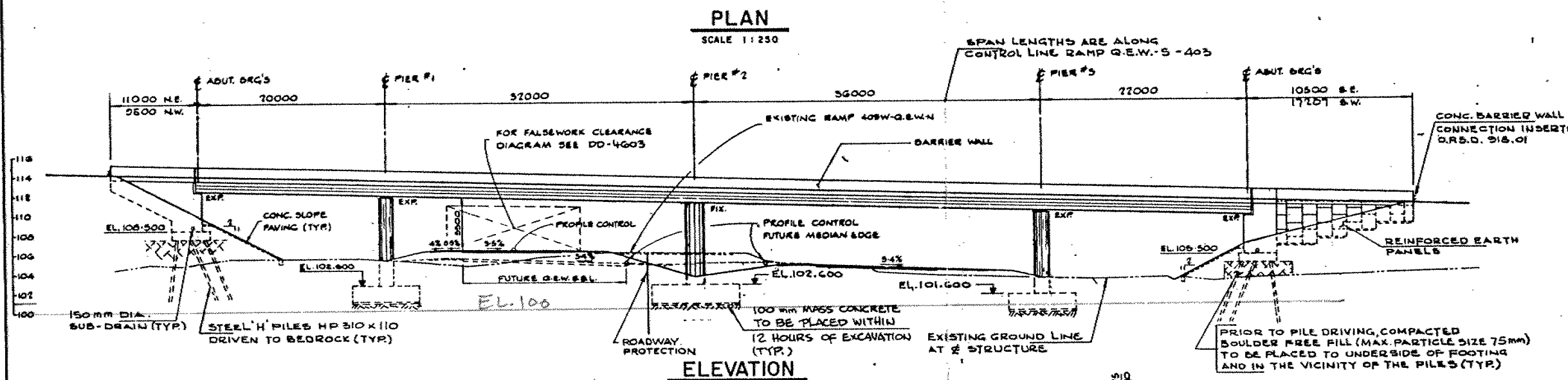
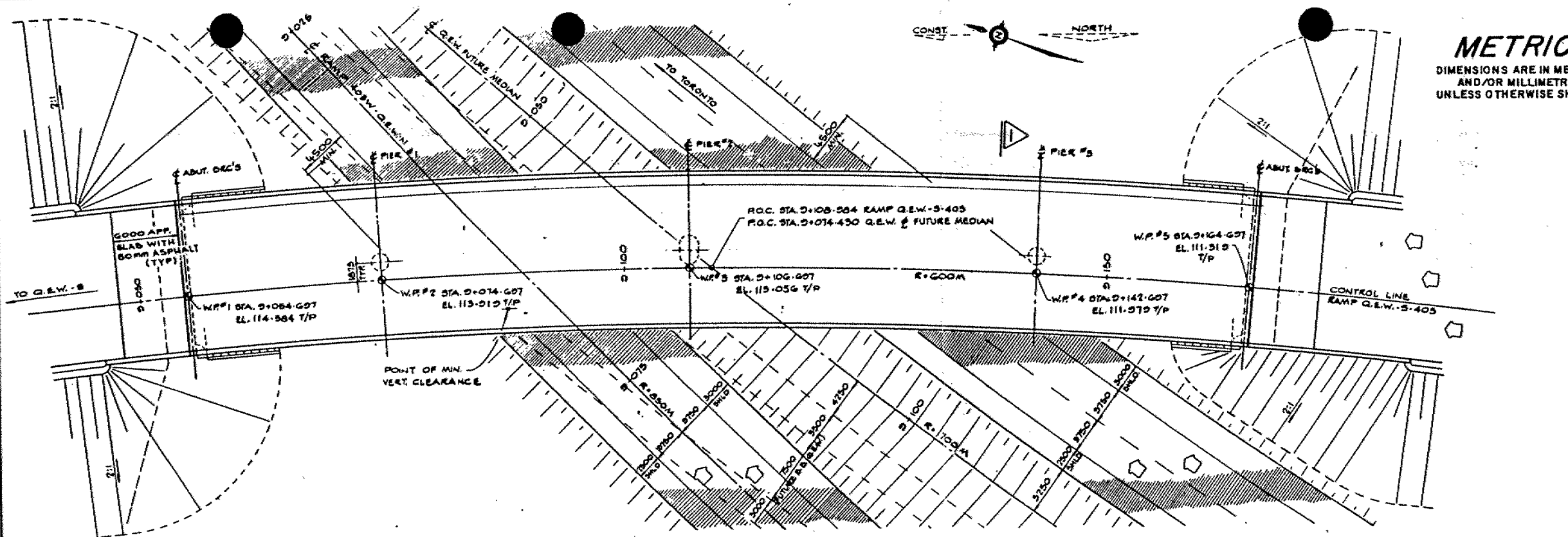
DIST. 4
CO No 85-62
WP No 83-74-28

NORTH

SHEET

Q.E.W. N.B.L. - RAMP S TO HWY. 403
UNDERPASS
GENERAL ARRANGEMENT

McCORMICK RANKIN
CONSULTING ENGINEERS



W.P. - DENOTES WORKING POINTS.
T/P - DENOTES TOP OF PAVEMENT.

K. WOOD-FAT
PROF. ENGINEER
ONTO.

R. SKELTON
PROF. ENGINEER
ONTO.

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

- GENERAL NOTES**
- CLASS OF CONCRETE**
- | | |
|-----------------------|--------|
| DECK AND PIER COLUMNS | 35 MPa |
| REMAINDER | 30 MPa |
- REINFORCING STEEL**
- GRADE 408 UNLESS OTHERWISE SPECIFIED.
BAR MARKS WITH SUFFIX 'C' DENOTE COATED BARS.
- CLEAR COVER TO REINFORCING STEEL**
- | | |
|----------------------------------|----------|
| FOOTINGS | 100 ± 25 |
| ABUTMENTS & WINGWALLS: | |
| FRONT FACE | 50 ± 20 |
| BACK FACE | 70 ± 20 |
| PIER COLUMNS | 50 ± 20 |
| DECK: | |
| TOP | 70 ± 20 |
| BOTTOM AND SIDES | 50 ± 10 |
| REMAINDER UNLESS OTHERWISE NOTED | 70 ± 20 |
- CONSTRUCTION NOTES**
- IF THE ACTUAL BEARING HEIGHTS ARE DIFFERENT FROM THE ASSUMED HEIGHTS GIVEN WITH THE BEARING DESIGN DATA, THE CONTRACTOR SHALL ADJUST THE BEARING SEAT ELEVATIONS AND THE REINFORCING STEEL TO SUIT THE ACTUAL HEIGHTS.
- LIST OF DRAWINGS**
- GENERAL ARRANGEMENT
 - CONSTRUCTION STAGES & ROADWAY PROTECTION
 - BOREHOLE LOCATION & SOIL STRATA
 - FOUNDATION LAYOUT
 - FOUNDATION REINFORCING
 - PIERS & BEARINGS
 - NORTH ABUTMENT
 - SOUTH ABUTMENT
 - REINF. EARTH RETAINING WALL I
 - REINF. EARTH RETAINING WALL II
 - DECK LAYOUT
 - LONGITUDINAL STRESSING
 - TRANSVERSE STRESSING
 - DECK REINFORCING I
 - DECK REINFORCING II
 - EAST BARRIER WALL
 - WEST BARRIER WALL
 - APPROACH SLABS
 - EXPANSION JOINT
 - DETAILS OF CONC. SLOPE PAVING
 - AS CONSTRUCTED ELEV. & DIMENSIONS
 - STANDARDS
 - ELECTRICAL EMBEDDED WORK I
 - ELECTRICAL EMBEDDED WORK II
 - QUANTITIES - STRUCTURE
 - QUANTITIES - STRUCTURE

APPLICABLE STANDARD DRAWINGS

DD 3503 MINIMUM GRANULAR BACKFILL REQUIREMENTS.

OPSD-918.01 CONNECTION TO NEW STRUCTURES.

DD-4603 FALSEWORK CLEARANCES

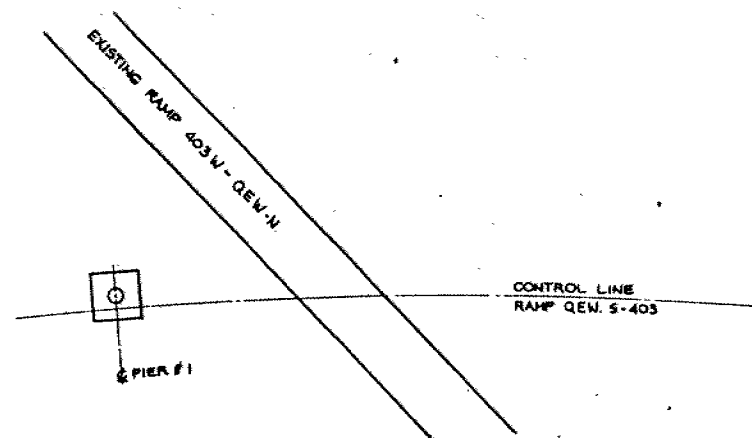
REVISIONS	DATE	BY	DESCRIPTION

DESIGN J.L.	CHECK R.S.	LOADING OHBOC-A-83	DATE APR 80
DRAWING B.J.A.	CHECK K.W.F.	SITE No 40-320	DWG

DIS CONT WP	No 85-62 No 83-74-28	SHEET
Q.E.W. N.B.L. - RAMP S TO HWY. 403 UNDERPASS CONSTRUCTION STAGES & ROADWAY PROTECTION		
McCORMICK RANKIN CONSULTING ENGINEERS		

METRIC

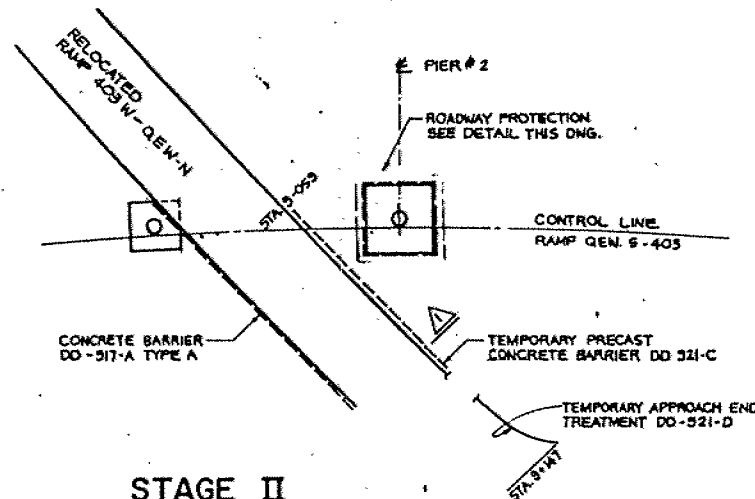
DIMENSIONS ARE IN MILLIMETRES
UNLESS OTHERWISE SHOWN.
ELEVATIONS, COORDINATES, CURVE
AND ALIGNMENT DATA ARE IN METRES.
STATIONS ARE IN KILOMETRES + METRES.



STAGE I

1:500

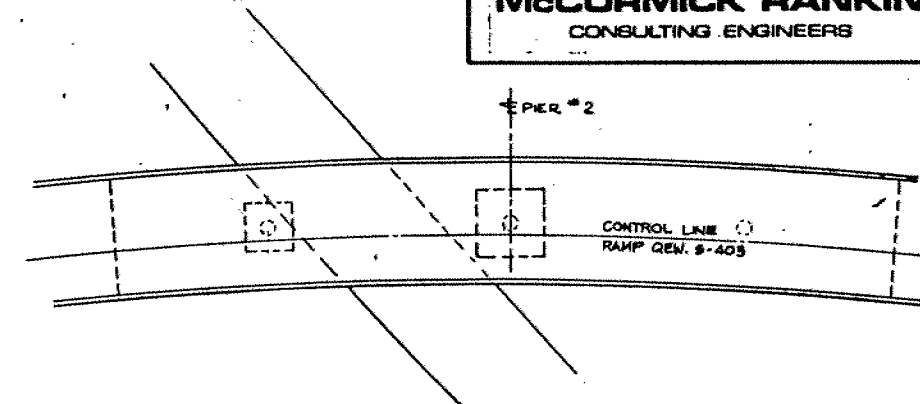
- CONSTRUCT FOOTING AND COLUMN FOR PIER #1



STAGE II

1:500

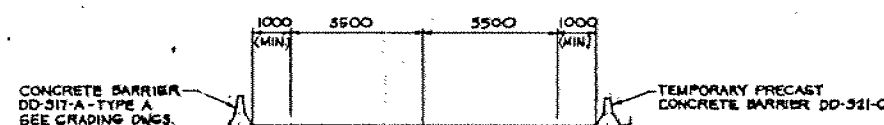
- BACKFILL EXCAVATION FOR PIER #1
- RELOCATE RAMP 403 W - QEW-N
- CONSTRUCT FOOTING AND COLUMN FOR PIER #2 INCLUDING ROADWAY PROTECTION



STAGE III

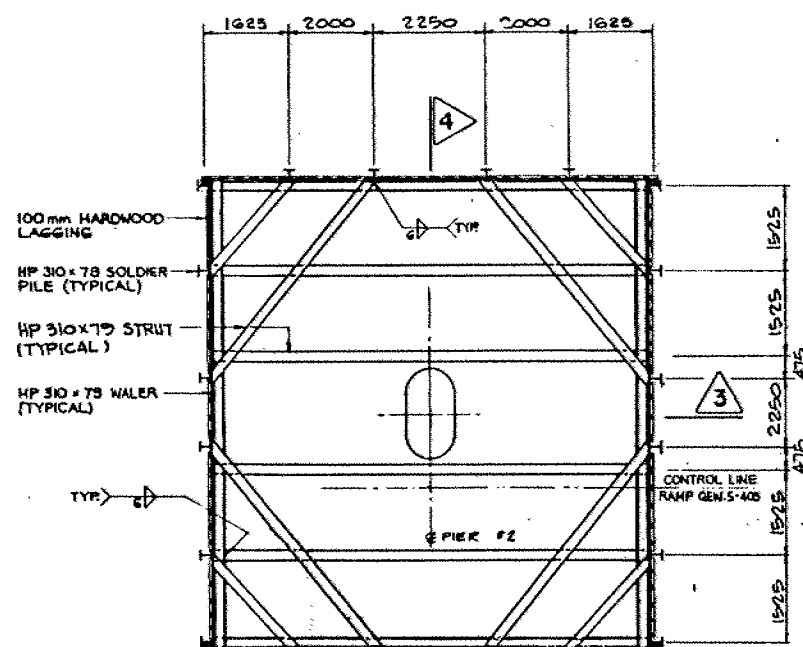
1:500

- COMPLETE THE STRUCTURE



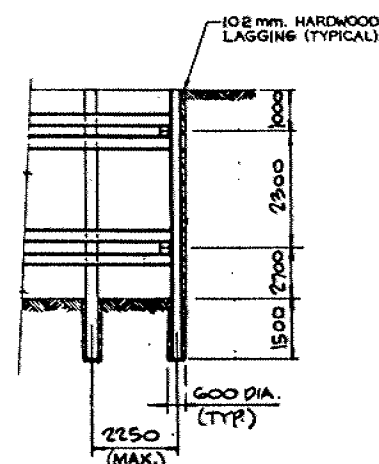
SECTION 1

1:100



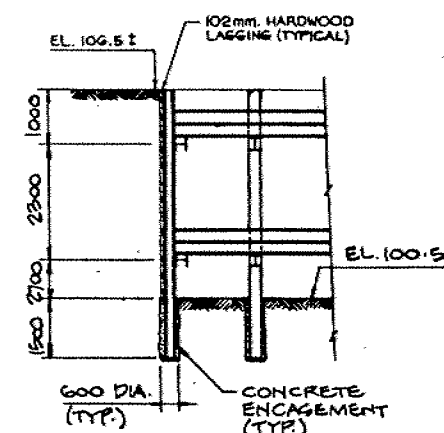
PLAN

N.T.S.



SECTION 3

N.T.S.



SECTION 4

N.T.S.

NOTES:

1. LAGGING TO BE ROUGH - 102mm. HARDWOOD.
2. STRUCTURAL STEEL TO BE SUPPLIED IN ACCORDANCE WITH C.S.A. S40.21 M - 300W.
3. CONCRETE FOR PILE ENCASUREMENT - 30 MPa.
4. WELDING OF STRUCTURAL STEEL SHALL CONFORM TO C.S.A. STD. W59-M1984.
5. ALL SHORING TO BE REMOVED TO 1000mm BELOW FINISHED GRADE.

APPLICABLE STANDARD DRAWINGS

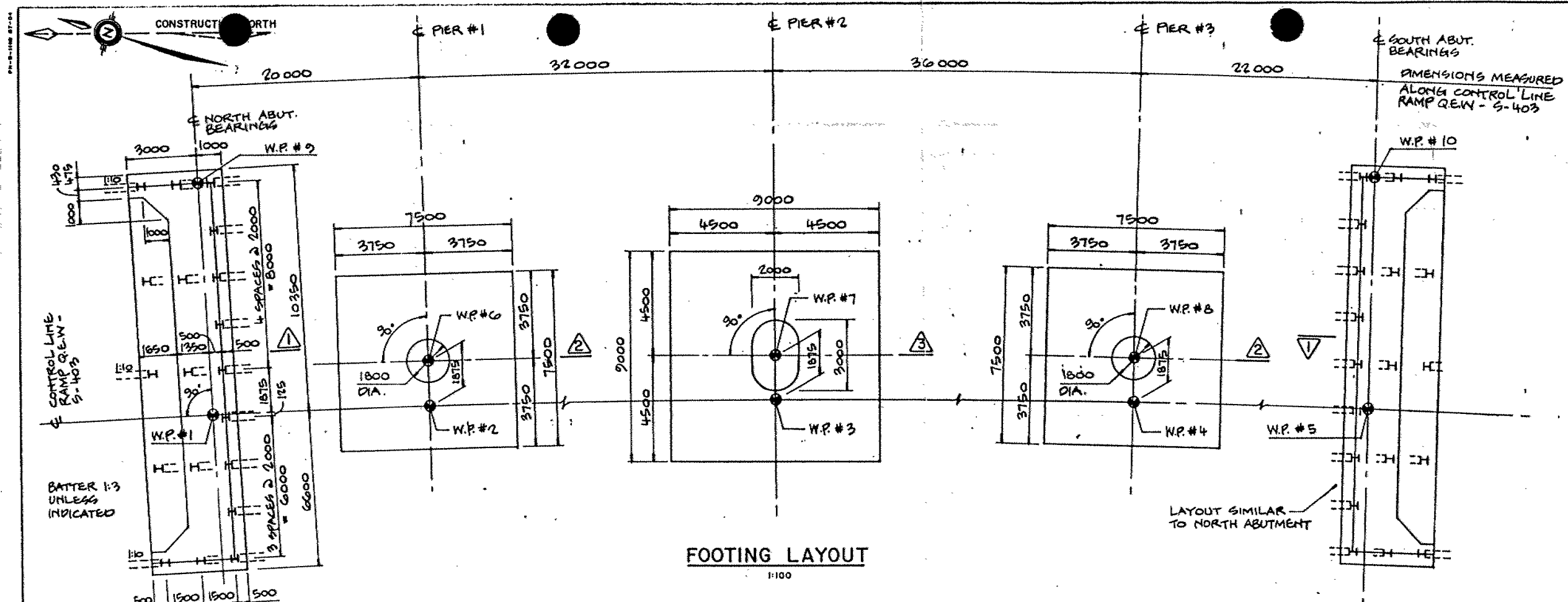
DD-4603 FALSEWORK CLEARANCES



DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION

SUGGESTED ROADWAY PROTECTION SCHEME

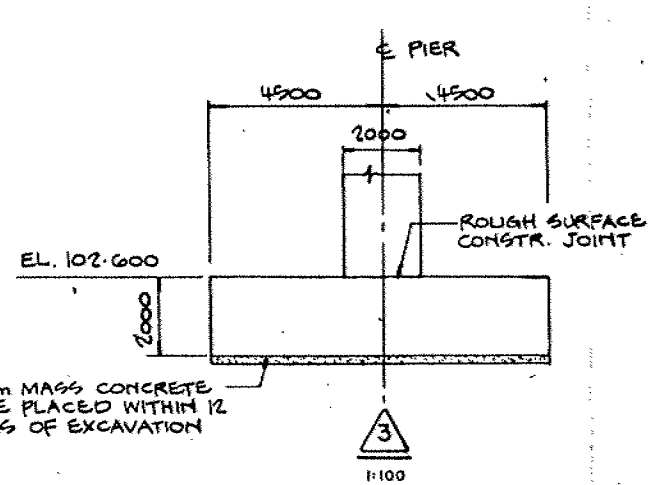
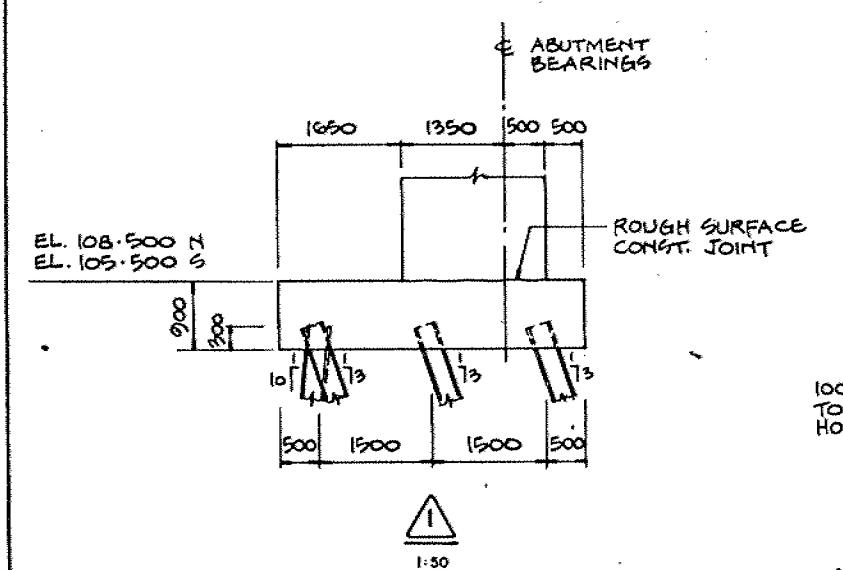


DIS
CONT No 85-62
WP No 83-74-28

Q.E.W. N.B.L. - RAMP S TO HWY. 403 UNDERPASS
FOUNDATION LAYOUT

McCORMICK RANKIN
CONSULTING ENGINEERS

- NOTES**
1. PILES TO BE 310HP X 110 STEEL.
 2. PILE LENGTHS SHOWN ARE THEORETICAL LENGTHS BELOW THE CUT-OFF ELEVATION.
 3. PILE LAYOUT DIMENSIONS ARE TO BE MEASURED AT THE UNDERSIDE OF FOOTINGS.
 4. ALL PILES HAVE DRIVING SHOES

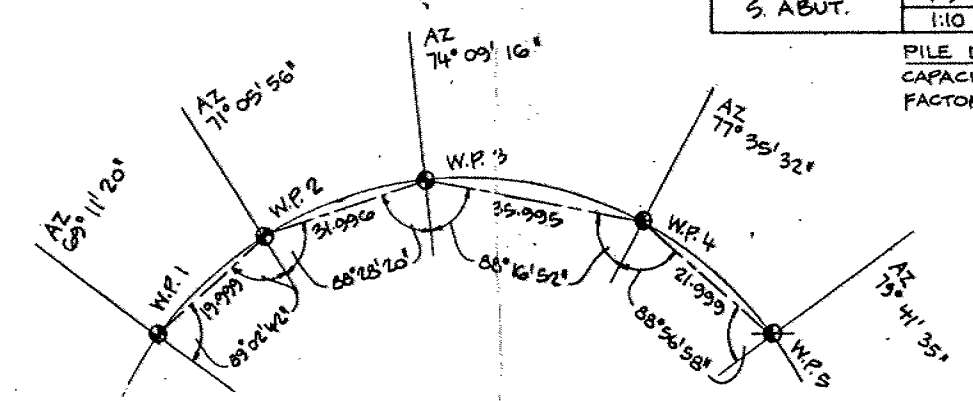
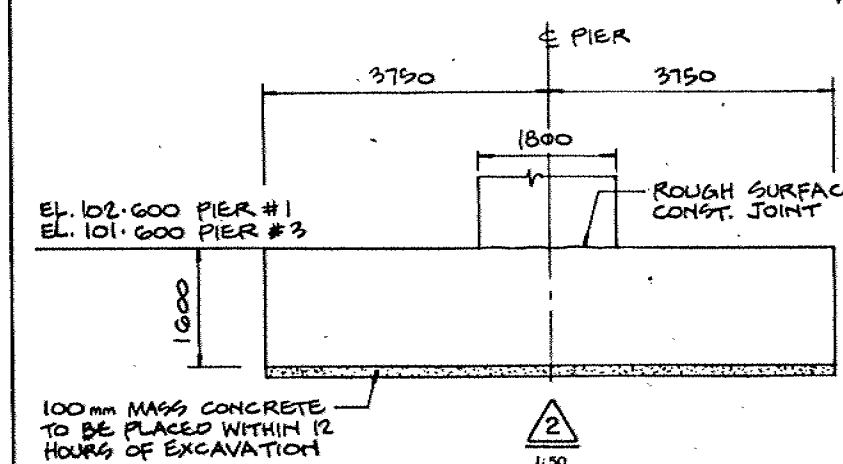


WORK POINT	STATION	CO-ORDINATES	
		NORTH	EAST
#1	9+054.697	4799624.509	278129.564
#2	9+074.697	4799605.698	278136.356
#3	9+106.697	4799575.162	278145.911
#4	9+142.697	4799540.256	278154.696
#5	9+164.697	4799518.688	278159.028
#6	9+074.697	4799606.306	278138.130
#7	9+106.697	4799575.674	278147.714
#8	9+142.697	4799540.699	278156.526
#9	9+054.697	4799628.017	278138.794
#10	9+164.697	4799520.455	278168.743

PILE DATA				
LOCATION	BATTER	QTY	LENGTH	CUT-OFF ELEV.
N. ABUT.	1:3	17	9.4 m	107.900
	1:10	2	8.3 m	107.900
S. ABUT.	1:3	17	6.5 m	104.900
	1:10	2	6.2 m	104.900

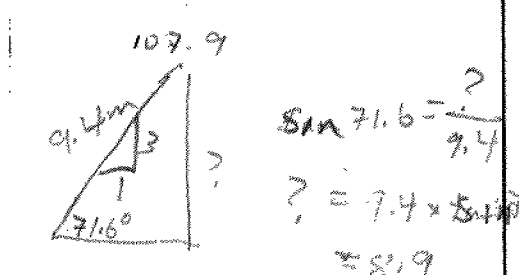
PILE DESIGN DATA
CAPACITY AT SLS II — 1150 KN
FACTORED CAPACITY AT ULS — 1600 KN

TIP EL.	VERTICAL LENGTH
99.8	8.9
98.4	8.7
98.7	6.8
	6.2



DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION



APPLICABLE STANDARD DRAWINGS
DD-3301 SPLICE & DRIVING SHOE DETAILS FOR STEEL 'H' PILES

Abutment Tip EL. Vertical Length
N 1:3 103 4.9
100 4.9

memorandum



To: G. Al-Bazi
Design Engineer
7th Floor, Atrium Tower

From: Foundation Design Section
Room 315, Central Building

Re: Q.E.W. NBL - Ramp S to Hwy. 403 Underpass
W.P. 83-74-28, Site 10-320
Hwy. 403, District 4, Burlington

Date: 1990 10 16

The final drawing No's 1, 2, and 4 for the above noted project were reviewed and the following comments are submitted.

- 1) It appears that the piles for the north and south abutments will have to be driven through 1.8 m to 4.0 m of shale bedrock.
- 2) Based on the bedrock condition, the actual pile length may be expected to vary substantially from the pile lengths indicated in the drawing No: 4.
- 3) The working concrete pad for pier foundations should be placed within 6 hours of exposure.


P. Payer, P. Eng.
Sr. Foundation Engineer

for

M. Devata, P. Eng.
Chief Foundation Engineer

MD/PP/jb

**McCORMICK, RANKIN & ASSOCIATES
LIMITED**

consulting engineers

October 19, 1981

Mr. Ken Selby, P. Eng.
Senior Foundation Engineer
Pavement & Foundation
Design Section
Room 313
Central Building
1201 Wilson Avenue
DOWNSVIEW, Ontario
M3M 1J8

RE: QEW South - Hwy. 403
Ramp Over
QEW N.B.L. & S.B.L.
Sites 10-320 & 10-321
W.P. 83-74-28 & 29
District 4, Hamilton
Our File: W.O. 1183-100 & 200



Dear Sir:

This letter will confirm our telephone conversation dated October 9th with you regarding foundation application of O.H.B.D.C. for the above mentioned projects.

W.P. 83-74-28 & 29

1) Spread Footings on Weathered Shale

(El. 103.3 to 101.1 for site 10-320)
(El. 104.7 to 103.8 for site 10-321)

Factored Capacity at U.L.S.	600 KPa
Capacity at S.L.S. type II	400 KPa
Friction coefficient between soil and base	tan 10.35°

2) Spread Footings in Granular Fill at Abutments

Factored Capacity at U.L.S.	600 KPa
Capacity at S.L.S. type II	350 KPa
Friction coefficient between soil and base	0.50

3) Piles Driven to Bedrock - 310 HP @ 110 Steel Piles

Factored Capacity at U.L.S.	1600 KN
Capacity at S.L.S. type II	1150 KN

.....

-2-

Mr. Ken Selby, P. Eng.

All H - piles shall be equipped with reinforced tips.
In addition, soil properties should be computed as per subsection
6.6.1.2.2 of the O.H.B.D.C.

If you have any questions, regarding this criteria,
please call.

Yours very truly,

McCORMICK, RANKIN & ASSOCIATES LIMITED

John Lam P. Eng

John Lam, P. Eng.

JL:rs

cc: Mr. W. Lin, P. Eng.

SEND
TO

G. AL-BAZI

STRUCTURAL OFFICE

7TH FLOOR, ABRIUM TOWER

FROM

P. PAYER

FOUNDATION DESIGN

DATE

90 04 30

SUBJECT

WP. 83-74-28

RECOMMENDED FOOTING LEVELS

PILES: $4\phi 310 \times 110$; U.L.S: 1600 KN; S.L.S. TYPE II: 1150 KN
 PILE TIP LEVELS: NORTH ABUT. EL. 103.0; SOUTH ABUT. EL. 102.0
 ALTERNATIVE: ABUTMENTS ON COMPACTED GRANULAR 'A' CORRE;
 U.L.S: 900 KPa; S.L.S. TYPE II: 340 KPa.

PIERS: THE BASE OF THE FOOTINGS SHOULD NOT BE HIGHER
 THAN: EL. 103 (PIER #1), EL. 102.5 (PIER #2) AND EL. 101.2 (PIER #3)
 BUT THE FROST PENETRATION DISTANCE OF NOT LESS THAN
 1.2 m SHOULD BE KEPT.

P. Payer

REPLY

REPLY FROM

REPLY DATE

COPY

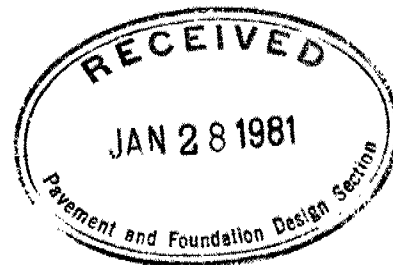


Golder Associates

CONSULTING GEOTECHNICAL AND MINING ENGINEERS

January 16, 1981

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



ATTENTION: Mr. K. Selby, P. Eng.
Senior Foundation Engineer

RE: FOUNDATION INVESTIGATION
PROPOSED BRIDGE
QEW/403 INTERCHANGE
W.P. 83-74-28; Site 10-320

Dear Sirs:

This letter reports the preliminary findings and recommendations of a subsurface investigation which was carried out by Golder Associates for the Ministry of Transportation and Communications, at the site of a proposed overpass bridge on the QEW/403 Interchange in Burlington, Ontario.

Details of the project were provided on a plan titled "Bridge Site, Proposed Northbound QEW Underpass at Ramp QEW-S to Hwy. 403" designated Site 10-320, dated September 30, 1980. This structure has been numbered W.P. 83-74-28 and forms part of an overall project under W.P. 83-74-07. It is understood that the proposed bridge will be a four span post-tensional type with spans of approximately 22 m, 45 m, 39 m and 22 m. It will allow for QEW northbound traffic to proceed westerly along Hwy. 403. The centre column is to be located at the median of the future QEW.

The following is a summary of the subsurface conditions encountered at Site 10-320 where 5 boreholes (BH 5 to 9 inclusive) were put down:

A layer of topsoil varying in thickness up to 0.3 m was encountered except at the location of the existing Hwy. 403 exit ramp to the QEW and at the southern end of the site near the existing QEW eastbound lanes. Near the exit ramp a borehole (BH 7) encountered 1.4 m of crushed stone (sand and gravel sizes). The topsoil and granular fill is underlain by clayey silt containing pieces of brick and thin lenses of black organic material, and is considered to be local fill. The fill varies in thickness from 0.6 m at the northern end of the site to 2.0 m at the exit ramp. The fill is underlain by hard clayey silt containing a trace of sand and gravel to sandy silt containing some gravel, with red shale fragments throughout. This stratum is considered to be residual soil rather than a glacial till due to the coarser fraction of the material being quite angular and friable. It extends to depths between 2.3 m and 4.4 m below ground surface.

The water content of the sandy silt is about 10 per cent and that of the clayey silt is about 17 per cent. Both materials (forming the residual soil) exhibit low plasticities with liquid limits between 16 to 22 per cent and a plasticity index of about 2. The residual soil is underlain by between 1.0 m and 2.0 m of highly weathered reddish brown weak shale and then followed by faintly weathered stronger shale. The shale is irregularly banded with limestone layers about 80 mm in thickness and an occasional thin red clay seam.

Based on the above findings the following alternative foundation designs are recommended at Site 10-320:

The bridge structures may be founded on shallow spread footings placed in the hard natural residual soil or weathered shale bedrock. An allowable bearing pressure of 320 kPa may be used for the design of footings placed approximately at a depth of 2 m into the natural soil, that is, between elevation 102.3 at the north end of the site to elevation 99.4 at the south end of the site. The footings may also be carried to competent shale bedrock which should be encountered about 2 m below the surface of the shale, that is, between elevation 101.2 and 98.1 m at the north end and south end of the site, respectively. An allowable bearing pressure of 640 kPa may be used for design of footings placed in the more competent shale.

All footings should be placed a minimum 1.2 m below final exterior grade for frost protection. To allow construction of footings placed below the groundwater level suitable shoring of the excavations will be required. The control of groundwater inflow by methods such as pumping from sumps will also be required. The base of all footing excavations should be inspected by a qualified geotechnical engineer prior to placement of any concrete.

Consideration should be given to the effect of high (up to 11 m) approach embankment loads on the settlement of bridge abutments. The embankment loads are apt to induce settlement of the underlying soils which in turn drags down the abutments. Since the bridge piers are not subjected to the same loading, the settlements are largely differential. In this case, although significant settlements are not anticipated, it would be prudent to extend the abutment footings to competent rock.

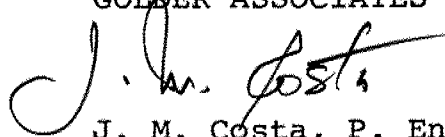
As an alternative to abutments on spread footings, consideration could be given to adopting perched abutments founded on piles driven through the embankment and end-

bearing on the competent shale bedrock which underlies the site between elevation 101.2 and 98.1 m. Steel H-piles, such as 12BP53 pile section driven to a set of 20 blows/25 mm using a driving energy of at least 54 kilo joules per blow may be designed using an allowable load of as much as 667.5 kN per pile.

We trust that these preliminary recommendations are sufficient for your immediate requirements. Should you have any questions concerning this letter, please contact us.

Yours truly,

GOLDER ASSOCIATES



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Q.E.W. South - Hwy. 403 W Ramp Over Q.E.W. N.B.L.
Site No. 10-320, W.P. 83-74-28
District 4, Hamilton

The foundation investigation program for the above mentioned project has now been completed by Golder Associates, geotechnical consulting engineers. Attached, please find their letter summarizing the subsurface conditions encountered across the site and the design recommendations pertaining to the structure foundations and related earthworks. The complete foundation investigation report and drawing for this site will be forwarded to you upon its receipt and review by this Section.

Additional comments with regards to the foundation recommendations are as follows:

- 1) Spread footings should be carried up from competent shale bedrock using mass concrete to effectively raise the founding elevation to an economic level.
- 2) For excavations carried down to shale bedrock, provisions should be made to pour a minimum 0.15 m thick slab of lean concrete over the base of the excavation immediately after excavation operations to prevent weathering of the exposed shale surface.
- 3) Steel 'H' section piles driven to bedrock should be equipped with reinforced flange plates at the pile tip to facilitate driving through the weathered shale.
- 4) On page 4 of the consultant's letter, the sentence should read "Steel H-piles, such as 310 HP 79 pile section driven to a set of 20 blows/25 mm using a driving energy of at least 54 kJ per blow may be designed using an allowable load of as much as 670 kN per pile."
- 5) In order to resist lateral forces acting on the abutment wall foundations, frictional forces between the footing and the underlying residual soil can be calculated using a coefficient of friction of 0.6. The lateral earth pressure exerted on the abutment wall by the granular backfill can be computed assuming a unit weight of 20.5 kN/m³ for the backfill and a coefficient of earth pressure ' K_0 ' of 0.5. Backfilling operations and

drainage measures should be carried out as per current M.T.C. standards.

- 6) Minimal settlement/stability problems are anticipated for the approach embankment fills and slopes provided they are constructed to a 2:1 geometry.

We trust the information provided is sufficient in scope for your immediate requirements. Should further discussion be warranted, please feel free to contact this Section.

TK:ea

T. Kazmierowski
Project Foundations Engineer

Attach.

cc: R. Fitzgibbon

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 30M5-123
30M5-124

DIST. 4 REGION

W.P. No. 83-74-29

CONT. No. 91-22

W. O. No.

STR. SITE No. 10-321

HWY. No. 403

LOCATION South of Q.E.W / Hwy 403
W Ramp

No of PAGES -

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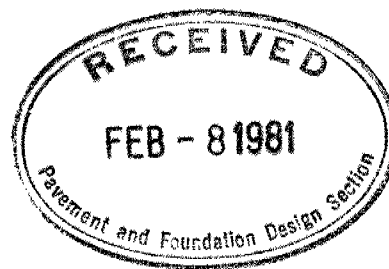
OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:



Golder Associates

CONSULTING GEOTECHNICAL AND MINING ENGINEERS



REPORT
TO

MINISTRY OF TRANSPORTATION
AND COMMUNICATIONS

FOUNDATION INVESTIGATION
PROPOSED OVERPASS BRIDGES AT Q.E.W./
HWY. 403

W.P. 93-74-28

DISTRICT 4

W.P. 93-74-29 CONT 91-22

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January, 1981

801-1341

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GEOLOGES " " = 124

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ABSTRACT

A subsurface investigation was carried out by Golder Associates for the Ministry of Transportation and Communications at the site of two proposed overpass bridges on the QEW/403 Interchange in Burlington, Ontario.

In summary, the borings indicate that stiff to hard clayey silt fill overlies a hard clayey to sandy silt (residual soil) stratum which overlies Queenston shale bedrock at depths between 1.5 and 2.3 m below existing ground surface. The shale bedrock is highly weathered for the top two metres. Groundwater levels measured during the investigation were at or just above the fill/residual soil contact and generally follow the surface topography.

The proposed structures may be founded in the natural soil or in competent bedrock. Perched abutments placed within the embankment fill may be adopted. Depending on the tolerance of the proposed structures to differential settlement these abutments may be placed directly on specially prepared fill or founded on piles driven through the embankment and bearing on bedrock.

1.0 INTRODUCTION

Golder Associates have been retained by the Ministry of Transportation and Communications (letter dated December 5, 1980) to carry out a foundation investigation for two proposed overpass bridges on the QEW/403 Interchange in Burlington, Ontario (overall W.P. 837407).

The purpose of the investigation was to determine the subsurface conditions at the site and based on these data, to provide engineering recommendations for the geotechnical design of the foundations for the proposed structures.

The investigation was carried out, and this report was prepared, in accordance with Golder Associates' letter, dated December 23, 1980.

2.0 DESCRIPTION OF PROJECT

Details of the project were provided during a meeting between Mr. Selby of the Ministry of Transportation and Communications, and Messrs. Davis and Busbridge of Golder Associates on December 15, 1980. Additional details were provided on two plans titled "Bridge Site, Proposed Northbound QEW Underpass at Ramp QEW-S to Hwy. 403" designated Site 10-320, W.P. 837428-A, dated September 30, 1980, and "Bridge Site, Proposed Southbound QEW Underpass at Ramp QEW-S to Hwy. 403" designated Site 10-321, W.P. 837429-A, dated October 1, 1980, and in an M.T.C. memorandum dated October 27, 1980. It is understood that the above mentioned projects form part of overall W.P. 837407.

It is understood that at Site 10-320, the proposed bridge will be a four span post-tensioned type with spans of approximately 22 m, 45 m, 39 m and 22 m. It will allow for QEW northbound traffic to proceed westerly along Hwy. 403. The centre column is to be located at the median of the future QEW.

At Site 10-321 it is understood that the proposed bridge will be a three span post-tensioned type with spans of approximately 20 m, 40 m and 20 m. It will allow for traffic carried by the previous bridge deck to overpass the future QEW southbound lanes and proceed westerly along Hwy. 403.

The approximate locations of the footings were shown in red on the two plans provided, along with profiles of both QEW and the ramps under consideration in this area.

3.0 SITE AND GEOLOGY

The proposed bridges are to be located along the QEW, south of the North Service Road and west of Brant Street in the City of Burlington, Ontario. The topography at the site is generally flat lying having an elevation about 106 m (Geodetic). Immediately to the north of the site the land rises towards the Niagara Escarpment.

The site is located in the physiographic region known as the Iroquois Plain, consisting of a narrow strip of land along the shores of the present Lake Ontario. This level plain was formed by post-glacial Lake Iroquois which then occupied the Lake Ontario basin. In the Burlington area the surficial soils in this plain consist of beach sands, clayey silt till and/or residual red clayey silt derived from weathering of the underlying Queenston shale bedrock. The Queenston shale formation consists of thinly bedded red clay shale with occasional bands of grey limestone.

4.0 INVESTIGATION PROCEDURE

The field work for this investigation was carried out between December 22 and 31, 1980. The elevations of the boreholes were determined on January 5, 1981. During this time nine boreholes were put down at the two sites (Drawings 837428-A and 837429-A) using a Type 5.3.i drillrig supplied and operated by Master Soil Investigations Ltd., of Toronto, a specialist drilling contractor. Within the overburden soils the boreholes were advanced with solid stem augers. In each

boring, standard penetration tests were carried out at 0.76 m intervals of depth, and samples were obtained using a standard 50 mm O.D. split spoon sampler, which was advanced by a 63.5 kg mass falling freely for 0.76 m. In each boring, bedrock was cored for depths of between 2.8 m to 3.8 m in BXL size. Details of the drilling and sampling operations are summarized on the Record of Borehole sheets. A filtered standpipe was sealed into each boring to allow monitoring of the groundwater level.

The field work was supervised throughout by a member of Golder Associates' engineering staff, who located the borings in the field, cleared underground services, directed the drilling and sampling operations, logged the borings and cared for the samples. The borehole locations were established by tape measurement. The ground surface elevations at each boring was determined relative to an M.T.C. survey monument (Drawing 837428-A). The elevation of this control point was provided by a member from the M.T.C. staff on January 8, 1981. It is understood that all ground surface elevations are referred to Geodetic datum.

Following field identification and logging, all the samples obtained during the investigation were placed in air-tight containers and brought to our laboratory where they were examined in detail. Representative samples of the soil were tested to determine their index properties.

5.0 SUBSURFACE CONDITIONS

The detailed stratigraphy encountered in each of the boreholes together with the results of laboratory tests carried out on representative samples of the soil strata are given on the attached Record of Borehole sheets and on Figures 1 to 3. The locations of the boreholes and the simplified stratigraphy at the boreholes are shown on Drawings 837428-A and 837429-A. It should be noted that the stratigraphic boundaries indicated on the borehole logs and longitudinal sections are inferred from a transition from one soil type

to another and do not necessarily indicate an exact plane of geologic change. Further, the subsurface conditions may vary between boreholes.

5.1 Site 10-320

At the locations of Boreholes 5, 6 and 8, up to 0.3 m of topsoil was encountered at ground surface. A layer of granular material comprising crushed stone (sand and gravel sizes) was encountered at Borehole 7 and extends to a depth of 1.4 m (Elev. 104.8 m). This material forms part of the shoulder of the existing Highway 403 exit ramp to the QEW. The topsoil at Boreholes 5, 6 and 8, the granular fill at Borehole 7 as well as ground surface at Borehole 9 are underlain by a layer of clayey silt containing some sand and gravel, pieces of red brick and occasional thin lenses of black organic matter. This fill varies in thickness from 0.6 m at Boreholes 5 to 2.0 m at Borehole 7. The fill is underlain by hard (N^* values greater than 30) clayey silt containing a trace of sand and gravel to sandy silt containing some gravel, with red shale fragments throughout.

The clayey silt material has a grain size distribution (Figures 1 and 2) similar to that of a glacial till. However, the coarser fraction of the soil is angular and easily friable. This material has the characteristics of a residual soil (soil material with the original texture, structure and mineralogy of the rock completely destroyed) rather than the matrix of a glacial till. It extends to a depth of about 2.3 m (between Elev. 100.1 m to 103.2 m) below ground surface except at Borehole 7 where it extends to 4.4 m (Elev. 101.8 m) below ground surface. The fill has a grain size distribution similar to that of the residual soil (Figure 1 - BH7, SA 3) and is probably local material placed during previous construction activities.

The water content of the sandy silt is about 10 per cent and that of the clayey silt is about 17 per cent. Both

*N - Standard Penetration Resistance - See Explanation of Terms, Appendix A.

materials (forming the residual soil) exhibit low plasticities with liquid limits between 16 to 22 per cent and a plasticity index of about 2 (Figure 3). The residual soil encountered at Boreholes 5 and 9 is more granular (Figure 2) than that of Boreholes 6, 7 and 8, possibly due to it containing more weathered shale fragments. This material is underlain by highly weathered to faintly weathered, reddish brown, weak to strong Queenston shale. The shale is irregularly banded with grey limestone layers about 80 mm in thickness and an occasional thin seam of red clay. The core recovery was generally in excess of 70 per cent and the Rock Quality Designations (RQD) lies between zero and 80 per cent, the higher quality being recorded for core recovered about 2 m below the overburden/bedrock interface.

As is evidenced from the profile shown on Drawing 837428-A ground surface and the various stratigraphic units slope gently from north (BH 5) to south (BH 9). The top surface of the residual soil also slopes towards the south but is more erratic due to the surface having been changed by previous construction activities and fill placement. The elevation of Borehole 7 is higher than the other boreholes in the same general area due to it being located near the southern shoulder of the exit ramp from Hwy. 403.

The groundwater surface measured in the standpipes also slopes towards the south generally following the ground surface topography.

5.2 Site 10-321

At the location of Boreholes 1 to 4 the ground surface is underlain by between 0.12 and 0.36 m of topsoil. At Boreholes 3 and 4, the topsoil overlies a layer of fill composed of clayey silt containing some sand and gravel, pieces of red brick and occasional thin lenses of black organic matter. The fill extends to a depth of 1.1 and 0.5 m (Elev. 104.9 and 105.1 m) below ground surface at the location of these two boreholes. The topsoil at Boreholes 1 and 2 and the fill at

Boreholes 3 and 4 is underlain by between 0.7 and 1.6 m of stiff to hard (N values 17 to 39) reddish brown clayey silt containing a trace of sand and gravel and numerous red shale fragments, and is considered to be residual soil. The residual soil was penetrated to about 1.5 to 1.8 m (Elev. 103.8 to 104.7 m) below ground surface at which depths refusal to augering was encountered. The higher 'N' values given on the Record of Borehole sheets and on the profile shown on Drawing 837429-A were obtained at the overburden/bedrock contact.

The water content of the residual soil lies between 11 and 16 per cent which is below the plastic limit of the material and indicative of a heavily overconsolidated soil. The material exhibits low plasticity with a plasticity index of about 10 (Figure 3).

Bedrock was extracted by BXL rock coring techniques. The bedrock was found to be a highly weathered to faintly weathered at depth, reddish brown, weak to strong at depth, Queenston shale. The shale is irregularly banded with grey limestone layers about 80 mm in thickness and is occasionally intercepted by thin seams of red clay. The core recovery was about 73 per cent and the RQD was between zero and 60 per cent and generally below 50 per cent. This indicates that the shale bedrock is of generally poor to fair quality.

The groundwater level measured within the standpipes slopes towards the south, generally following the surface topography. Although the water level is indicated as being higher at Borehole 3 than at Borehole 2 this may be due to an interceptor ditch located near Borehole 2 thereby depressing the water level in this area.

6.0 DISCUSSION AND RECOMMENDATIONS

The recommendations for the geotechnical aspects of design of the proposed structures, together with the comments on the construction aspects of the work contained

in this section of the report are for the guidance of the design engineer only. Contractors bidding on or undertaking the works should make their own interpretation of the factual information provided as it affects their proposed construction methods, equipment selection, scheduling and the like.

6.1 Bridge Foundations

The natural soils and rock found at the site are suitable for the support of approach embankments and bridge foundations. Depending on the most economical proportioning of footing dimensions and excavation requirements, together with the tolerance of the proposed structure to differential settlement, various options may be considered.

6.1.1 Bearing Pressure - Site 10-320

At Site 10-320 the bridge may be founded on shallow spread footings placed in the hard natural residual soil and/or weathered shale. An allowable bearing pressure of 320 kPa may be used for the design of footings placed at least 2 m into the natural residual soil and/or weathered shale bedrock which underlie the site between elevation 102.3 m (BH 5) and 99.4 m (BH9).

As an alternative to founding the proposed structure in the residual soil and/or weathered shale, consideration should be given to carrying the footings to competent shale bedrock which should be encountered about 2 m below the surface of the shale, that is, at approximately between elevations 101.6 m (BH 6) and elevation 99.1 m (BH 9). An allowable bearing pressure of 640 kPa may be used for design of footings placed in the more competent shale.

6.1.2 Bearing Pressures - Site 10-321

The bridge structure at this site may be founded on shallow spread footings founded at least 2 m into the hard natural residual soil and/or weathered shale which underlies

the site. An allowable bearing pressure of 320 kPa may be used for the design of footings placed at least 2 m into the natural residual soil and/or weathered shale bedrock.

As an alternative to founding the proposed structure in the residual soil and/or weathered shale, the footings may be founded on competent shale bedrock which should generally be encountered at about elevation 103 m. An allowable bearing pressure of 640 kPa may be used for design of footings placed in competent shale. It should be stressed that at the location of BH 1 the highly weathered shale bedrock extends down to at least elevation 101.7 m and was not penetrated. Footings extending to competent shale bedrock will have to be founded at a lower elevation in this area.

6.2 Special Considerations for Abutments

Consideration should be given to the effect of high (up to 10 m) approach embankment on the settlement of bridge abutments. The embankment loads are apt to induce settlement of the underlying soils which in turn drags down the abutments. Since the bridge piers are not subjected to the same loading, the settlements are largely differential.

6.2.1 Abutments on Spread Footings

Where abutments are placed on the residual soil or highly weathered shale bedrock it is anticipated that a differential settlement of up to 50 mm could develop between the abutment and the adjacent bridge pier. This can be reduced to less than 25 mm by ensuring that footings are taken down to the competent shale as discussed in 6.1.1 and 6.1.2.

Where the abutments are required to act as retaining walls the lateral earth loads will depend on the type and method of placement of the fill materials. The following recommendations are made in respect to the design of the

abutment retaining walls:

- (i) Selected granular fill, such as M.T.C. Granular 'B' should be used as backfill immediately behind the structures. The granular fill should be placed in the wedge-shaped zone defined by a 45 degree line extending up and back from the rear face of the structures' footings;
- (ii) All granular fill should be compacted in 200 mm thick lifts to 95 per cent of the standard Proctor dry density of the material. However, heavy compaction equipment should not be used behind any structure within a lateral distance equal to the current height of the fill above the base of the structure;
- (iii) Provided that the above criteria are satisfied, a coefficient of active earth pressure (K_a) of 0.3 may be used in computing lateral earth pressures, if an outward deflection of approximately 1/2 per cent of the wall height can be tolerated at the bridge bearings. If this amount of deflection cannot be absorbed, than an at-rest coefficient of earth pressure (K_o) equal to 0.5, should be used in calculating the lateral earth pressures. A coefficient of friction less than or equal to 0.55 may be assumed between the concrete footings and the bedrock. A bulk unit weight of 20 kN/m^3 may be assumed for the Granular 'B' backfill;
- (iv) An adequate drainage system should be provided behind the abutments to prevent build-up of hydrostatic forces. The drainage system should include a properly designed filter to prevent clogging of the pipes. Provision should be made to allow cleaning or rodding of the pipes, should they become clogged.

6.2.2 Perched Abutments

As an alternative to abutments on spread footings consideration could be given to adopting perched abutments placed within the embankment fill. Depending on the degree of continuity of the bridge deck structure and therefore its tolerance to differential settlement these abutments can be supported on specially prepared embankment material or on piles driven through the embankment fill.

Where no piling is used it will be necessary to remove all existing fill and to replace with granular fill, compacted to a minimum of 100 per cent of the Standard Proctor density. The granular material should extend from the underside of the abutment down to the natural soil at a slope of 2 horizontal to 1 vertical. Material within 1.5 m of the underside of the abutment should conform to M.T.C Granular 'B' specification. An allowable bearing pressure of 200 kPa may be used for the design of the abutment footing provided it is placed a minimum of 3 m from the face of the slope measured at the founding level. Where the bridge structure cannot tolerate a differential settlement of 75 mm between abutment and pier it is recommended that perched abutments are founded on piles driven through the embankment fill.

The piles should be founded on the shale bedrock. Steel H-pile section HP310 x 79 driven to a set of 20 blows/25 mm using a driving energy of at least 54 kilo joules per blow will be capable of supporting a working load of 700 kN per pile.

6.3 General Considerations

All footings should be placed a minimum 1.2 m below final exterior grade for frost protection.

To ensure that the footings are placed on relatively undisturbed natural residual soil, weathered shale or

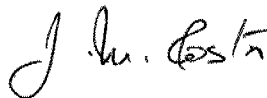
competent bedrock, it is recommended that the base of all footing excavations be inspected by a qualified geotechnical engineer prior to placement of any concrete.

6.4 Comments on Construction

It is anticipated that it will be possible to excavate the top 4 m of shale by ripping although progress may be slow where bands of limestone are encountered. The ingress of water into the excavations must be prevented as water will soften the shale. Further, the foundations should not be exposed any more than necessary and should not be left open overnight. A coating of working concrete should be applied to the foundation surface as soon as possible after excavation.

In order to allow construction of footings placed below the groundwater level, suitable shoring of the excavations will be required. The control of groundwater inflow by methods such as pumping from sumps will also be required.

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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/0.3m)	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 (R Q D), FOR MODIFIED RECOVERY, IS:

R Q D (%)	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

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

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 = $\frac{c_u}{\tau_r}$

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

W P 837429-A LOCATION Co-ords 4.799.746N; 278.076 E (STA B+ 921) ORIGINATED BY A.H.T.
 DIST 4 HWY OEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
 DATUM Geodetic DATE December 22, 1980 CHECKED BY J.S.C.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						
								SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE		10 20 30				
106.24	Ground Level													GR SA SI CL
0.00	Topsoil						Seal 106							
0.36	Clayey Silt with shale fragments (Residual soil). Hard.		1	SS	39		Backfill							0 6 70 24
104.72	Red and Greenish Grey.		2	SS	50/127 mm		105							
1.52	Shale Bedrock. Highly weathered reddish brown, fine grained, weak, irregularly banded with grey limestone layers about 80mm thick. 76mm clay seam at Elev. 103.3 m.		3	R.C. BXL	95%		104							RQD 31%
101.70			4	RC BXL	89%		Pea Gravel 103							RQD 9%
4.54	End of Borehole.						102							
							101							W.L. elev 105.17 on Jan.5, 1981

RECORD OF BOREHOLE No.2

W P 837429-A LOCATION Co-ords 4,799,727 N; 278,084 E (STA B+942.5) ORIGINATED BY A.H.T.
 DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
 DATUM Geodetic DATE December 23, 1980 CHECKED BY J. Smith

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
106.33	Ground Level																
0.00	Topsoil						Seal 106										
0.24	Clayey Silt, some shale fragments (residual soil).						Backfill										
	Very Stiff.		1	SS	17												
104.50	Reddish Brown.																
1.83	Shale bedrock, highly weathered, reddish brown, fine grained, weak.		2	SS	25												
	32mm clay seam at Elev. 103.7 m.		3	RC BXL	91%												RQD 18%
103.28	Shale Bedrock.																
3.05	Faintly weathered reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		4	RC BXL	100%												RQD 30%
							Pea Gravel										
			5	RC BXL	100%												RQD 42%
101.21	End of Borehole.																W.L. elev. 104.44 on Jan. 5/81
5.12																	

RECORD OF BOREHOLE No. 3

W P 837429-A LOCATION Co-ords 4,799,692 N; 278,102 E (STA B+982.5) ORIGINATED BY A.H.T.
 DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
 DATUM Geodetic DATE December 23, 1980 CHECKED BY J.H.C.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
105.96	Ground Level																
0.00	Topsoil																
0.12	Clayey silt (Fill).																
104.89	Hard. Brown to Black.		1	SS	17												
1.07	Clayey silt, with shale fragments (Residual Soil).																
104.19	Hard. Reddish brown.		2	SS	115/279												
1.77	Shale Bedrock. Highly weathered. Reddish brown, fine grained, weak.		3	RC BXL	73%												
103.16	Shale Bedrock. Faintly weathered, reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		4	RC BXL	92%												
2.80			5	RC BXL	100%												
101.33																	
4.63	End of Borehole.																



RECORD OF BOREHOLE No.4

W P 837429-A LOCATION Co-ords 4,789,673 N; 278,111 E (STA 9+002.5) ORIGINATED BY A.H.T.
DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
DATUM Geodetic DATE December 23 & 24, 1980 CHECKED BY J.L.F.


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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
105.56	Ground Level																
0.00	Topsoil						Seal										
0.12	Clayey Silt (Fill).						105										
105.10	Stiff, Brown.																
0.46	Clayey Silt, some gravel and shale fragments (Residual Soil).		1	SS	23		Backfill										3 13 73 11
103.79	Hard, Reddish Brown.		2	SS	84		104										
1.77	Shale Bedrock.			Rc													RQD 53%
103.33	Moderately Weathered,																
2.23	Shale Bedrock. Faintly weathered, reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		3	BXL	98%		103										
			4	Rc			Pea Gravel										
				BXL	97%		102										RQD 33%
100.96							101										Standpipe frozen at ground level on Jan. 5/81
4.60	End of Borehole.						100										

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No. 5

W P 837428-A LOCATION Co-ords. 4,799,633 N; 278,130 E (STA 9+047) ORIGINATED BY A.H.T.
 DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
 DATUM Geodetic DATE December 29, 1980 CHECKED BY J.M.C.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
105.42	Ground Level																
0.00	Topsoil						Seal										
105.12	Clayey to Sandy Silt (Fill).		1	SS	15		105										
104.65	Stiff Red to Dark Brown		2	SS	28												
0.91	Sandy silt, some gravel, trace clay (Residual Soil).					Backfill	104										
			3	SS	76												16 34 42 8
103.27	Dense, Reddish Brown.		4	SS	65/100 mm		103										RQD 0%
2.29	Shale Bedrock. Slightly Weathered. Reddish brown, fine grained, strong.		5	RC BXL	11%												
	Irregularly banded with grey limestone layers about		6	RC BXL	97%		102										RQD 48%
101.29	80 mm thick.						101										
4.27	Shale Bedrock. Faintly weathered reddish brown, fine grained, strong.		7	RC BXL	101%	Pea Gravel	100										RQD 73%
99.68	about 80 mm thick.																W.L. Elev. 104.87 on Jan. 5/81
5.88	End of Borehole.						99										

+3, x5: Numbers refer to
Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No.6

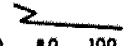
W P 837428-A LOCATION Co-ords. 4,799,610N; 278,139E (STA. 9+071) ORIGINATED BY A.H.T.
DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
DATUM Geodetic DATE December 29, 1980 CHECKED BY A.C.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20						40
105.47	Ground Level													
0.0	Topsoil													
0.15	Clayey to Sandy Silt, some gravel (Fill).		1	SS	17	Seal								
			2	SS	18									
103.67	Compact, Brown.		3	SS	38	Backfill								
1.80	Clayey Silt, some gravel (Residual Soil).													
103.13	Hard, Reddish Brown.		4	SS	70/1	Seal								
2.34	Shale Bedrock. Moderately weathered reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		5	RC BXL	98%									
3.84	Shale Bedrock, Faintly weathered reddish brown, fine grained, strong. Irregularly banded with grey limestone layers about 80 mm thick.		6	RC BXL	100%	Pea Gravel								
99.80	End of Borehole.													
5.67														



RECORD OF BOREHOLE No. 7

W P 837428-A LOCATION Co-ords. 4,799,575N; 278,151E (STA. 9+108) ORIGINATED BY A.H.T.
DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
DATUM Geodetic DATE December 30, 1980 CHECKED BY J.H.C.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	N' VALUES			SHEAR STRENGTH										WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE										10 20 30				
106.22	Ground Level							20	40	60	80	100										
0.0	Crushed Stone (Sand and Gravel sizes) (Fill).						Seal 106															
104.85	Very Dense, Brown.		1	SS	59		105															
1.37	Clayey Silt, some sand, trace gravel (Fill).		2	SS	44		Backfill 104															
	Stiff to Hard.		3	SS	13		103										2 20 57 21					
102.84	Brown.		4	SS	40		102															
3.38	Clayey Silt, some sand, trace gravel and shale fragments (Residual Soil).		5	SS	60/152		Seal 102															
101.80	Hard. Reddish Brown.		6	SS	60/152		101															
4.42	Shale Bedrock. Highly weathered. Reddish brown. Fine grained. Weak.		7	RC BXL	39%		100										RQD 0%					
100.73	Shale Bedrock. Moderately weathered reddish brown, fine grained, strong. Irregular banded with grey limestone layers about 80 mm thick.		8	RC BXL	120%		99										RQD 53%					
5.49	Shale Bedrock. Faintly weathered. Reddish brown with irregular grey limestone bands.		9	RC BXL	78%		98										RQD 41%					
99.15	Shale Bedrock. Faintly weathered. Reddish brown with irregular grey limestone bands.		10	RC BXL	86%												RQD 86%					
98.08	Fine grained. Strong.																W.L. elev. 102.44 on Jan. 5/81					
8.14	End of Borehole.																					

+3, x5: Numbers refer to
Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No.8

W P 837428-A LOCATION Co-ords. 4,799,531N; 278,161E (STA. 9+152) ORIGINATED BY A.H.T.
 DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
 DATUM Geodetic DATE December 29 & 30, 1980 CHECKED BY J.L.C.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH					WATER CONTENT (%)				
103.01	Ground Level																
0.00																	
102.70	Topsoil																
0.31	Sandy Silt to Clayey Silt (Fill). Very Stiff. Brown.																
102.06																	
0.95	Sandy Silt to Clayey Silt with gravel (Residual Soil). Hard. Reddish Brown.		1	SS	35		102										
101.18			2	SS	65/152		101										
1.83	Shale Bedrock. Highly weathered. Reddish brown with irregular grey limestone bands about 80 mm thick. Fine grained. Weak,		3	RC BXL	44%		100										RQD 0%
99.11			4	RC BXL	100%		99										RQD 34%
3.90	Shale Bedrock. Slightly weathered. Reddish brown with irregular grey lime- stone bands about 80 mm thick. 75 mm clay seam at Elev. 99.1 m. Fine grained. Strong.		5	RC BXL	99%		98										RQD 45%
97.68			6	RC BXL	100%		97										RQD 100%
5.33	End of Borehole.																W.L. elev. 102.13 on Jan. 5/81

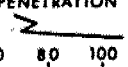
+3, x⁵: Numbers refer to
Sensitivity

20
15 \div 5 (%) STRAIN AT FAILURE
10

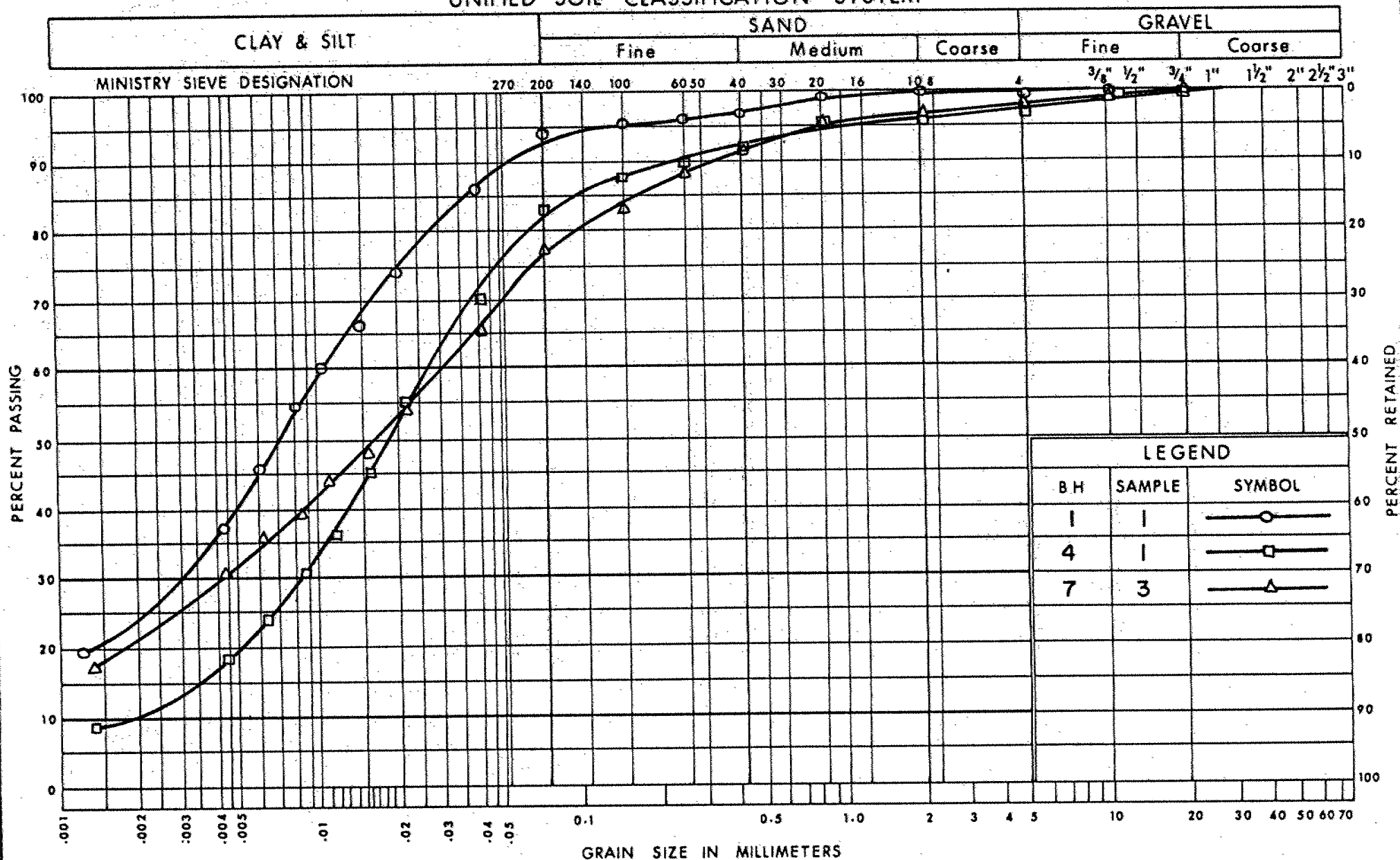
OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 9

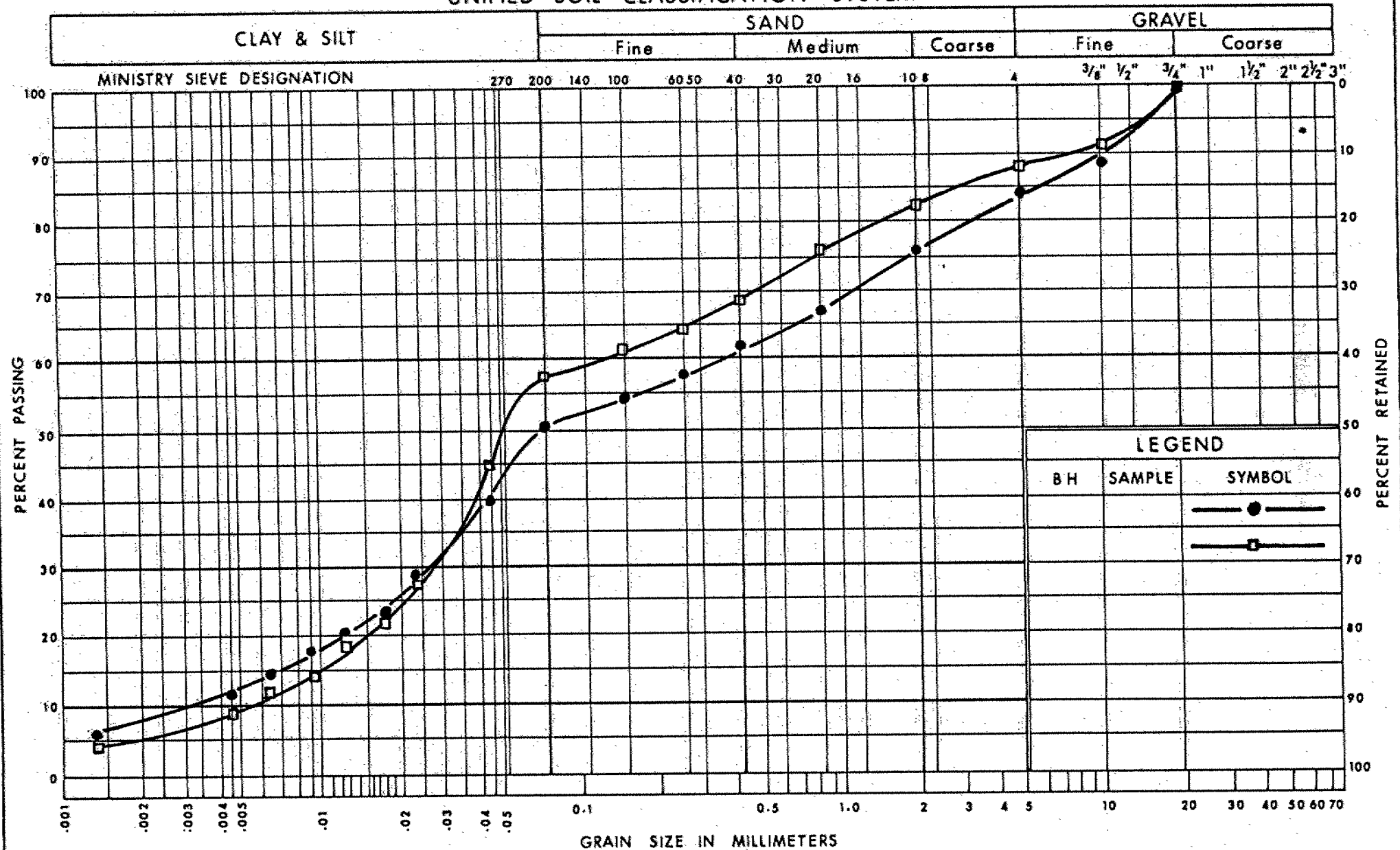
W P 837428-A LOCATION Co-ords. 4,799,508N; 278,165E (STA. 9+175) ORIGINATED BY A.H.T.
 DIST 4 HWY QEW/403 BOREHOLE TYPE Solid Stem Augers, BXL Rock Core COMPILED BY J.M.C.
 DATUM Geodetic DATE December 30 & 31, 1980 CHECKED BY J.H.C.

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 (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH							WATER CONTENT (%) 10 20 30
								O UNCONFINED		+ FIELD VANE		● QUICK TRIAXIAL			
102.44	Ground Level														
0.00	Clayey Silt to Sandy Silt, some gravel (Fill). Stiff.					Seal	102								
101.37	Dark brown to black, Sandy Silt, some gravel, trace clay (Residual Soil).		1	SS	19	Backfill	101							12 31 53 4	
100.15	v. dense. Reddish Brown.		2	SS	86										
2.29	Shale bedrock, slightly weathered reddish brown with grey limestone bands. Short vertical fracture at elev. 99.3 m.		3	SS	60/76	Seal	100							RQD 35%	
99.09	Fine grained. Strong.		4	RC BXL	88%									RQD 50%	
3.35	Shale bedrock, faintly weathered. Reddish brown with grey limestone bands about 80 mm thick. Clay seam at elev. 98.4 m.		5	RC BXL	98%		99								
96.95	Fine grained. Strong.		6	RC BXL	98%	Pea Gravel	98							RQD 70%	
5.49	End of Borehole.						97							W.L. elev. 101.74 on Jan. 5/81	
							96								

UNIFIED SOIL CLASSIFICATION SYSTEM



UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of
Transportation and
Communications

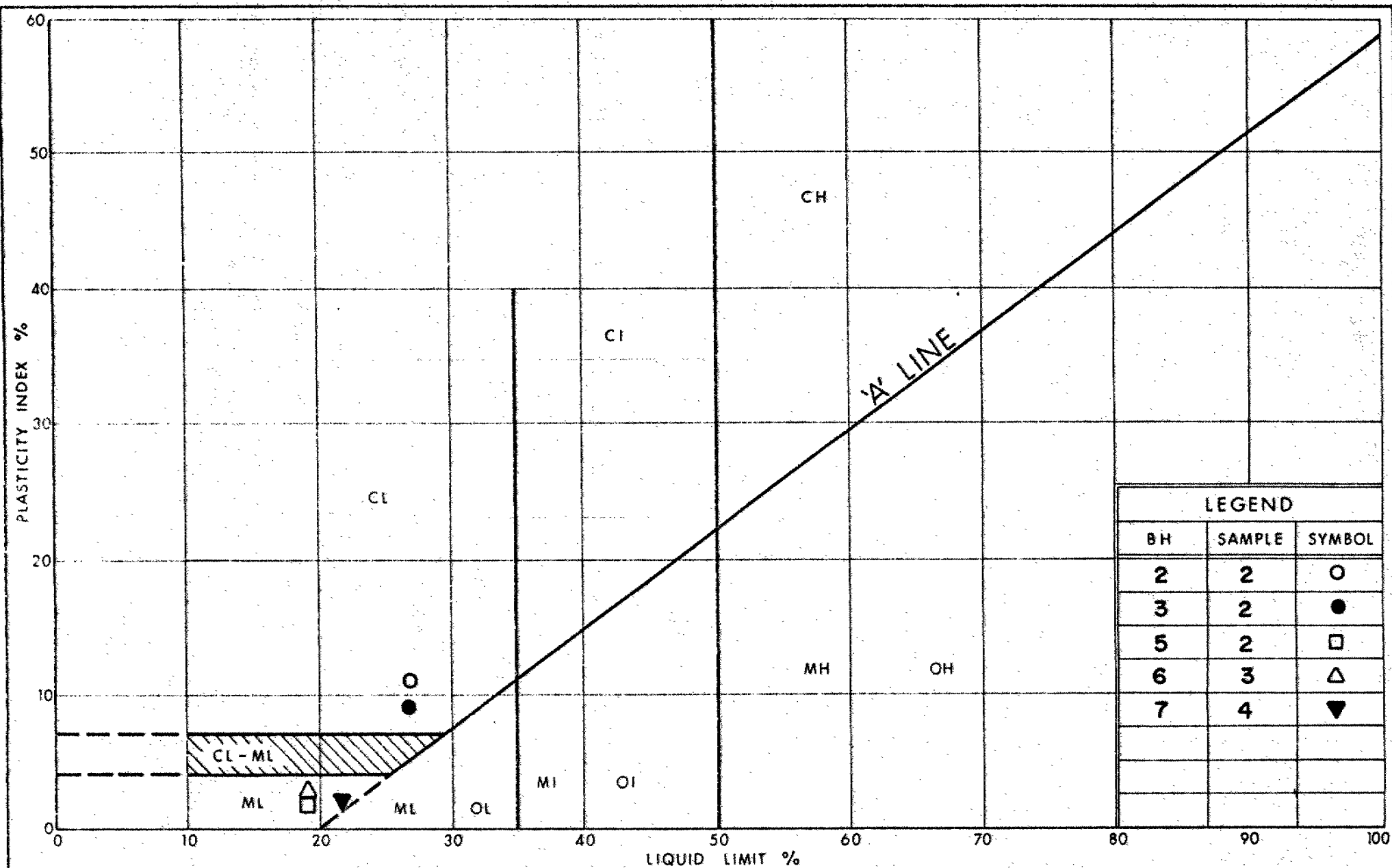
Ontario

ENGINEERING SERVICES BRANCH

GRAIN SIZE DISTRIBUTION SANDY SILT (RESIDUAL SOIL)

FIG No 2

W P 837407



LEGEND		
BH	SAMPLE	SYMBOL
2	2	○
3	2	●
5	2	□
6	3	△
7	4	▼



Ministry of
Transportation and
Communications

PLASTICITY CHART

FIG No 3

W P 837407 CT

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

Pavement & Foundation Design Section
Room 313, Central Building

81 02 18

Q.E.W. South - Hwy. 403 Ramp Over
Q.E.W. N.B.L. & S.B.L.
Sites 10-320 & 10-321
W.P. 83-74-28 & 29
District 4, Hamilton

The firm of Golder Associates, geotechnical consulting engineers, have completed the foundation investigation program for the above mentioned projects. Please find attached the final report and drawings for these sites which have been reviewed by this Section.

Our comments regarding recommendations pertaining to the structure foundations and related earthworks are as follows.

Pier foundations may be founded on spread footings located on the weathered shale interface. For design estimating purposes, footings found at elevations ranging from 103.3 to 101.1 for Site 10-320 and from elevation 104.7 to 103.8 for Site 10-321 can be designed for an allowable bearing pressure of 400 kPa. Mass concrete may be used to effectively raise the founding elevation of the spread footings from the weathered shale surface to an economic level.

Perched abutments in the approach fills as well as bridge piers may be founded on steel 'H' section piles equipped with reinforced tips driven to competent bedrock. For estimating purposes, 'H' piles driven to refusal into bedrock, at approximate tip elevations of 101 to 99 for Site 10-320 and elevation 103 for Site 10-321, can be designed for the maximum allowable compressive loading per pile section. Pile driving should be controlled in the field by the MTC Hiley Formula using a minimum driving energy of 50 kJ per blow.

Alternatively, the abutments can be founded on an engineered fill consisting of a well compacted Granular 'A' core designed as per MTC specifications. An allowable design loading of 240 kPa can be achieved for spread footings designed in this manner.

Minimal settlement/stability problems are anticipated for the approach embankment fills and slopes provided they are constructed to a 2:1 geometry.

continued...../2

We trust the information provided in this memo and the accompanying report is sufficient for your requirements. Should further discussions be warranted, please feel free to contact this Section.

TJK:ea

T.J. Kazmierowski
Project Foundations Engineer

Encl.

cc: G.C.E. Burkhardt
R.D. Gunter
I.V. Oliver
D.E. Thrasher
C. Grebski
B.J. Giroux
R. Hore

memorandum



To: G. Al-Bazi
Design Engineer
7th Floor, Atrium Tower

Date: 1990 10 16

From: Foundation Design Section
Room 315, Central Building

Re: Q.E.W. SBL - Ramp S. to Hwy. 403 Underpass
W.P. 83-74-29, Site 10-321
Hwy. 403, District 4, Burlington

The final drawing No's 1, 3 and 4 for the above noted project were reviewed and the following comments are submitted.

- 1) It appears that the piles for the north and south abutments will have to be driven through 1.0 m to 1.5 m of shale bedrock.
- 2) Based on the bedrock condition, the actual pile length may be expected to vary substantially from the pile lengths indicated in the drawing No: 4.
- 3) The working concrete pad for pier foundations should be placed within 6 hours of exposure.

A handwritten signature in black ink, appearing to read 'P. Payer'.

P. Payer, P. Eng.
Sr. Foundation Engineer

for

M. Devata, P. Eng.
Chief Foundation Engineer

MD/PP/jb

SEND
TO

G. AL-BAZI

STRUCTURAL OFFICE

7TH FLOOR, ABRIUM TOWER

FROM

P. PAYER FOUNDATION DESIGN

DATE

90 05 01

SUBJECT

RECOMMENDED FOOTING LEVELS, WP. 83-74-29.

PILE TIP ELEVATIONS

NORTH ABUT. EL. 104.5, SOUTH ABUT. 103.6

ALTERNATIVE: ABUTMENTS ON COMPACTED GRANULAR
'A' COREPIERS: SPREAD FOOTINGS ON BEDROCK

FOOTING BASE LEVELS: NORTH PIER: 104.0 OR LOWER,

SOUTH PIER: EL. 104.2 OR LOWER

THE FROST PROTECTION REQUIREMENT IS A MINIMUM
OF 1.2m OF EARTH COVER.

P. Payer

REPLY

REPLY FROM

REPLY DATE



Memorandum

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

From: Pavement & Foundation Design Section
Room 313, Central Building

Attention:

Date: 81 02 03

Our File Ref.

In Reply to

83-7729

Subject:

Q.E.W. South - Hwy. 403 W Ramp
Over Q.E.W. S.B.L.
Site 10-321, W.P. 83-74-29
District 4, Hamilton

Golder Associates, geotechnical consulting engineers, have completed the foundation investigation program for the above mentioned project and have submitted to us a draft copy of the final report for comments. In order to satisfy your scheduling and preliminary design requirements, this letter summarizes the subsurface conditions encountered across the site and presents design recommendations interpreted from the consultant's draft report. The complete foundation investigation report and drawing for this site will be forwarded to you upon its receipt and review by this Section.

Briefly, the predominate subsurface deposit underlying the site consists of a heavily overconsolidated silty clay of low plasticity containing a trace of sand and gravel with numerous shale fragments. 'N' values ranging from 17 to 39 blows per 0.3 m indicate a stiff to hard consistency for this residual soil. Shale bedrock was encountered at depths ranging from 1.5 to 1.8 metres below ground surface corresponding to elevations 104.7 and 103.8 respectively. In general, the upper 1 metre of the shale is highly weathered. Groundwater levels were found to vary between elevations 104.4 and 105.3, generally indicating a southward gradient across the site.

Recommendations pertaining to the structure foundations and related earthworks are summarized as follows.

Pier foundations may be founded on spread footings located on the weathered shale interface. For design estimating purposes, footings found at elevations ranging from 104.7 on the north extreme to 103.8 on the south can be designed for an allowable bearing pressure of 400 kPa. Mass concrete may be used to effectively raise the founding elevation of the spread footings from weathered shale to an economic level.

Perched abutments in the approach fills and also bridge piers may be founded on steel 'H' section piles equipped with reinforced tips driven to competent bedrock. For estimating purposes, 'H' piles driven to refusal into bedrock (approx. tip elevation of 103) can be designed for the maximum allowable compressive loading per pile section.

Pile driving should be controlled by the MTC Hiley Formula using a minimum driving energy of 50 kJ per blow.

Alternatively, the abutments can be founded on an engineered fill consisting of a well compacted Granular 'A' core designed as per MTC specifications. An allowable design loading of 240 kPa can be achieved for spread footings designed in this manner.

All footings and pier caps should be designed with a minimum of 1.2 metres of earth cover for frost protection purposes.

Provisions should be made to pour a minimum 0.15 m thick slab of lean concrete over the base of any foundation excavation carried down to bedrock immediately upon completion of the excavation.

In order to resist lateral forces acting on the abutment wall, frictional forces between the footing and the underlying bedrock can be calculated using a coefficient of friction of 0.55. The lateral earth pressure exerted on the abutment by the granular backfill can be computed assuming a unit weight of 20.5 kN/m³ for the backfill and a coefficient of earth pressure ' K_0 ' of 0.5. Backfilling operations and drainage measures should be carried out as per current MTC standards.

Minimal settlement/stability problems are anticipated for the approach embankment fills and slopes provided they are constructed to a 2:1 geometry.

In consideration of the relatively impervious nature of the residual soil, no extensive dewatering systems are required. Groundwater seepage into braced excavations should be controlled by pumping from perimeter sumps.

We trust the information provided is sufficient in scope for your immediate requirements. Should further discussion be warranted, please feel free to contact this Section.



T. Kazmierowski
Project Foundations Engineer

TK:ea

cc: R. Fitzgibbon

METRIC

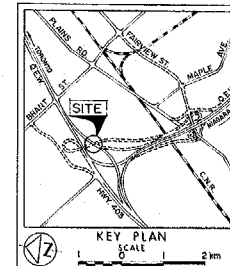
CONT No
WP No 837428-A



PROPOSED N/B Q.E.W. UNDERPASS
AT RAMP Q.E.W-S TO HWY 403
BORE HOLE LOCATIONS & SOIL STRATA

SHEET

GOLDER ASSOCIATES
CONSULTING GEOTECHNICAL ENGINEERS



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)
- Wt of time of investigation, JAN 15/91
- SEAL
- STANDPIPE

No	ELEVATION	CO-ORDINATES NORTHING	EASTING
5	105.422m	4 799 633m	278 130m
6	105.472	4 799 610	278 139
7	106.228	4 799 875	278 151
8	103.012	4 799 531	278 161
9	102.437	4 799 508	278 165

NOTE

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

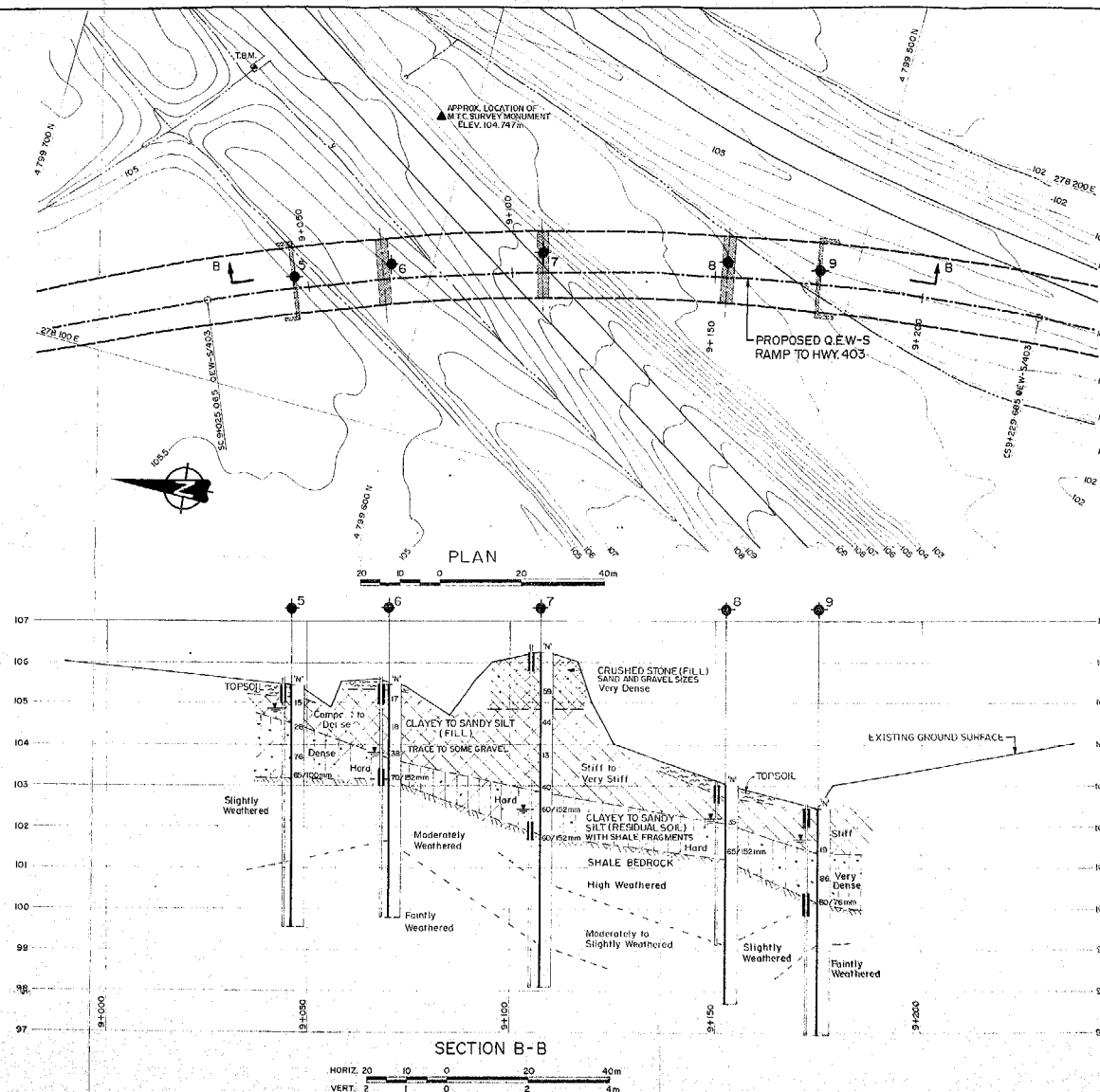
REVISED	DATE	BY	DESCRIPTION

Geocres No 3045-123

HWY No 403 / Q.E.W. NORTHBOUND U/PASS DIST 4

SUMMITT CHY CRED/ DATE JAN 14, 1991 SITE 10-320

DRAWN BY / CHECKED BY / DWG 837428-A



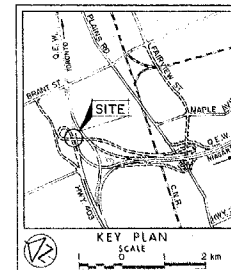
METRIC

CONT No
WP No 837429-A

PROPOSED S/B Q.E.W. UNDERPASS
AT RAMP Q.E.W-S TO HWY. 403
BORE HOLE LOCATIONS & SOIL STRATA

SHEET

GOLDER ASSOCIATES
CONSULTING GEOTECHNICAL ENGINEERS



LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ◆ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 175 J/blow)
- CONE Blows/0.3m (60° Cone, 175 J/blow)
- W.L. at time of investigation, JAN 5/81
- SEAL
- STANDPIPE

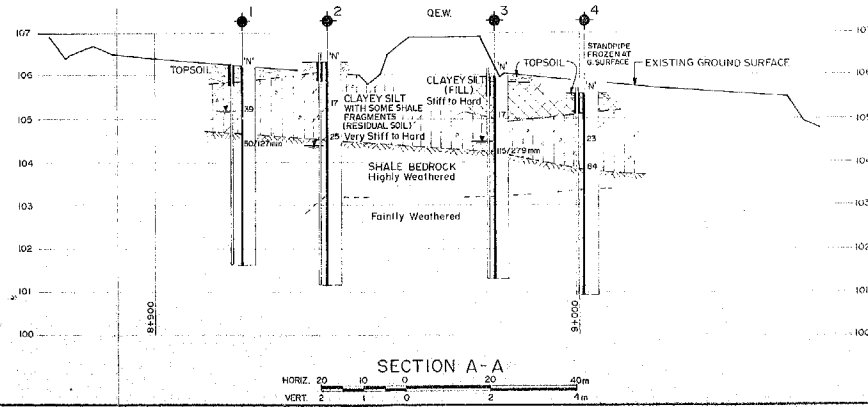
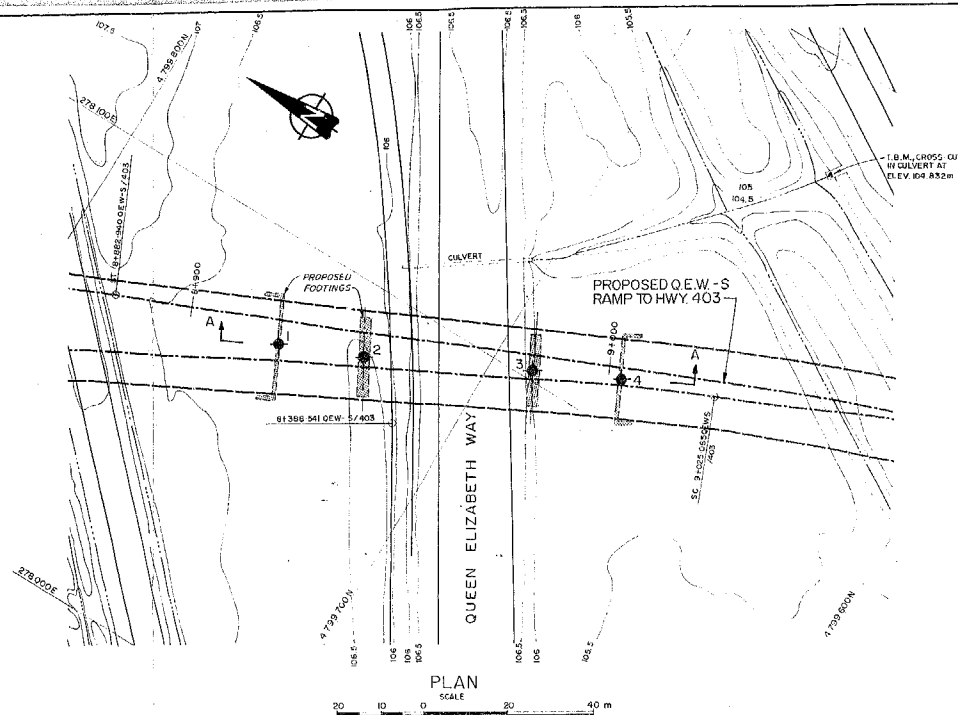
No	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
1	105.242m	4 799 748	278 076
2	105.352	4 799 727	278 064
3	105.957	4 799 692	278 102
4	105.562	4 799 673	278 111

NOTE

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

DATE	BY	DESCRIPTION

Geocres No 3045-124
HWY No 403 Q.E.W. SOUTH BOUND UNDERPASS DIST 5
CUMUL. CORRECTED DATE JAN 15, 1981 1176 10 - 321
DRAWN MW CHECKED J. P. HARRIS DWG 837429-A



METRIC

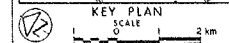
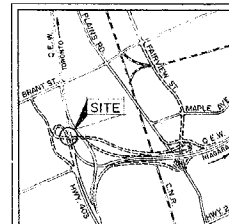
CONT No
WP No 837429-A

PROPOSED S/B Q.E.W. UNDERPASS
AT RAMP Q.E.W.-S TO HWY. 403
BORE HOLE LOCATIONS & SOIL STRATA



SHEET

GOLDER ASSOCIATES
CONSULTING GEOTECHNICAL ENGINEERS



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, JAN 5/91
- || SEAL
- STANDPIPE

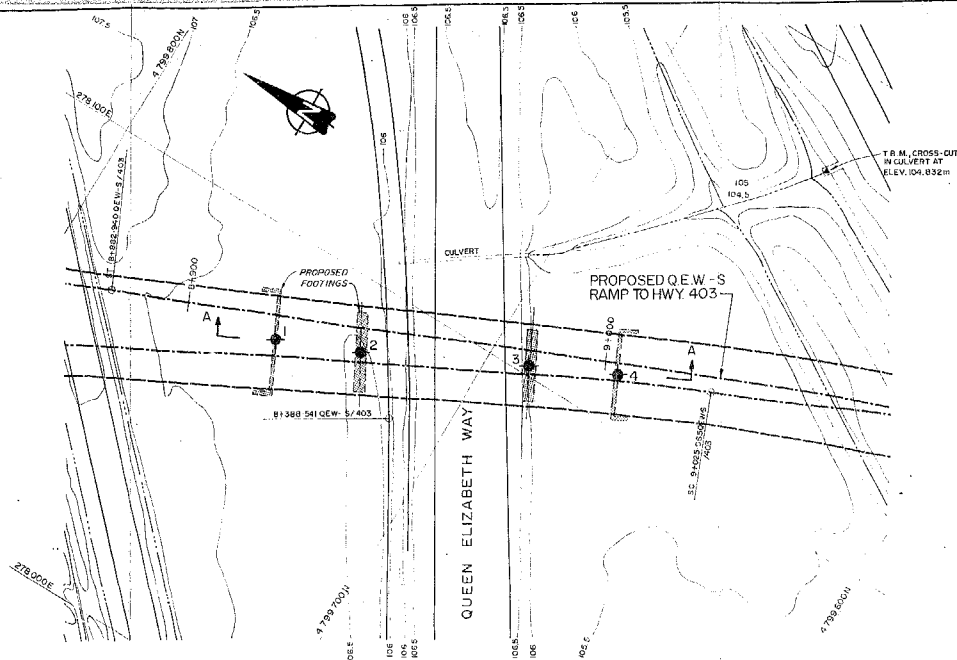
No	ELEVATION	CO-ORDINATES NORTHING EASTING
1	106.242m	4 790 746 278 076
2	106.332	4 790 727 278 084
3	105.997	4 790 692 278 102
4	105.562	4 790 673 278 111

NOTES

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

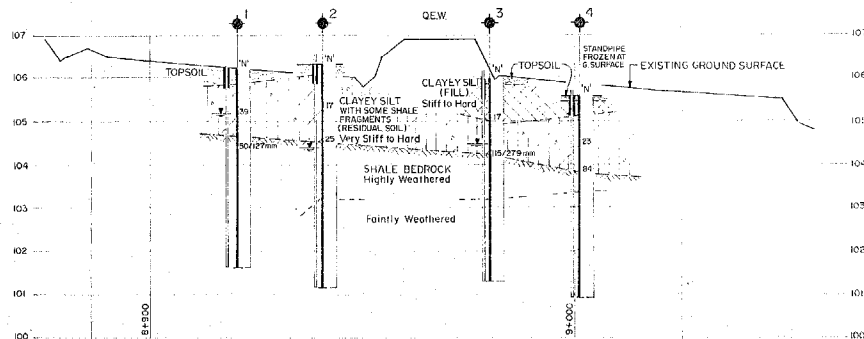
REVISIONS	DATE	BY	DESCRIPTION

Geotech No 30MS-124
Ramp No 403 Q.E.W. SOUTHBOUND UNDERPASS DIST 4
DUMD CHECKED DATE JAN 12, 1991 SITE 10-321
DRAWN M.W. CHECKED DATE 1/19/91 DWG 637429-A



PLAN

SCALE 20 10 0 20 40 m



SECTION A-A

HORIZ. 20 10 0 20 40 m
VERT. 2 1 0 2 4 m

Changed
to a
single span.
Informed J. J. Pandeyan
on March 9/91.

METRIC

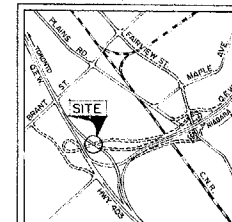
CONT No
WP No 837428-A

PROPOSED N/B Q.E.W. UNDERPASS
AT RAMP Q.E.W.-S TO HWY. 403
BORE HOLE LOCATIONS & SOIL STRATA



SHEET

GOLDER ASSOCIATES
CONSULTING GEOTECHNICAL ENGINEERS



KEY PLAN
SCALE
0 1 2 km

LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test [Cone]
- ⊕ Bore Hole & Cone
- N Blows/0.3m [Std Pen Test, 475 J/blow]
- CONC Blows/0.3m [60° Cone, 475 J/blow]
- W.L. at time of investigation, JAN 1981
- SEAL
- STANDPIPE

No.	ELEVATION	CO-ORDINATES	
		NORTHING	EASTING
5	105.422m	4799.633m	278.130m
6	105.472	4799.610	278.130
7	105.232	4799.575	278.151
8	103.012	4799.531	278.161
9	102.437	4799.508	278.165

NOTE

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

DATE	BY	DESCRIPTION

Geocres No 30MS-123
HWY. 403 Q.E.W. NORTHBOUND PASS DIST 4
SUBS. CHECKED DATE JAN 10, 1981 SITE 10-120
DRAWN MW CHECKED DATE 10-120 DWG 837428-A

