

G.I.-30 SEPT. 1976

GEOCRES No. 30M3-207DIST. CR REGION W.P. No. 335-89-00CONT. No. W. O. No. STR. SITE No. HWY. No. Q.E.W.LOCATION Retaining Walls at
Victoria Ave. InterchangeNo of PAGES - =====OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. REMARKS:

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FOUNDATION DESIGN SECTION

**foundation
investigation and
design report**

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 335-89-00 DIST Central
HWY QEW STR SITE

Retaining Walls
QEW Widening at Victoria Avenue Structure

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FOUNDATION INVESTIGATION REPORT

for

Retaining Walls

QEW Widening at Victoria Avenue Structure

W.P. 335-89-00, Burlington District, Central Region

Introduction

This report summarizes the factual information obtained from a foundation investigation carried out on 95 11 27 for retaining walls proposed at the abutments to the Victoria Avenue structure at the QEW. The fieldwork consisted of four sampled boreholes advanced by means of solid stem augers to depths of 6.3 m below ground surface.

Site Description

The site is located in the Town of Lincoln within the Regional Municipality of Niagara. This stretch of the QEW is surrounded largely by agricultural land use.

Physiographically, the site lies within the Iroquois Plain which is characterized by overburden consisting of fine grained and glacial till deposits overlying shale bedrock.

Subsurface Conditions

General

The surficial material encountered across the site is a fill deposit composed of non-cohesive to slightly cohesive silt. The thickness of the fill material varies from 1.1 to 4.2 m at the northwest quadrant of the structure where backfill and bedding material for an existing water line were encountered. The water main runs beneath the west embankment in a N-S direction, 6 to 7 m from the abutment edge. It continues beneath the QEW and south beneath the embankment fill at the south abutment. Its depth is assumed to be approximately El 80.0.

Underlying the fill material in all boreholes except BH 4, is a cohesive clayey silt to silt stratum containing trace to some sand. Occasional zones of non-cohesive sandy silt up to 1.4 m thick were identified in this soil layer. The clayey silt to silt deposit is underlain by a non-cohesive sandy silt glacial till. The presence of cobbles and boulders is likely in the glacial till deposit.

Shale bedrock of the Queenston Formation was proven during the investigation carried out for the existing structure. It was encountered at approximate elevation 76.2 m.

Groundwater levels were recorded at two of the four borehole locations, although the levels had not stabilized during the period of drilling. The water levels ranged from El. 80.5 to 83.1.

The boundaries of the various subsoil types are shown on the Record of Borehole Sheets. The locations and elevations of the borings together with stratigraphical sections inferred from the borehole data are shown on Drawing No. 3358900-A. Detailed subsurface descriptions follow.

Silt (Fill Material)

A largely non-cohesive fill deposit composed of silt was encountered at each of the borehole locations extending for depths of 1.1 to 2.1 m. A fill thickness of 4.2 m was measured at BH 4 where boring was carried out adjacent to an existing water main.

In BH's 1, 2, and 3 the silt material contains trace sand, trace gravel, and occasional zones of clayey silt. Standard Penetration Test N values range from 9 to 25, indicating a relative density ranging from compact to dense. At BH 4, the fill is also composed of trace to some organics. An N value of 22 was measured in the first sample followed by N values ranging from 0 to 5 below a depth of 1.5 m (El. 83.0). Hence, at BH 4, the fill deposit exhibits a compact crust overlying material in a very loose state.

The following properties were measured on representative samples of the fill deposit:

	<u>Range</u>	<u>Average</u>
Moisture Content (w%)	13.5 - 16.5	15.5
Plastic Limit (w _p %)	16.0 - 18.0	17.0
Liquid Limit (w _L %)	19.0 - 23.0	21.0
Plasticity Index (I _p)	1 - 7	

Clayey Silt to Silt

In BH's 1, 2, and 3 the native clayey silt to silt stratum underlies the fill deposit. The stratum was not present in BH 4. It was encountered between El. 80.7 and 82.7 and extends to El. 79.3. The thickness of the deposit varies from 3.1 to 3.8 m. At BH 2, the clayey silt to silt layer is intersected by zones of silty sand.

The clayey silt to silt stratum contains trace sand and trace gravel. Sand and gravel contents increase with depth. Below approximate El. 80.0, larger grain sizes were encountered and the presence of cobbles was identified during augering.

N values ranging from 10 to 60/10cm were measured within the deposit indicating a stiff to hard consistency. More typically the N values are greater than 20 and exhibit very stiff to hard consistency.

The following properties were measured on representative samples of the native deposit:

	<u>Range</u>	<u>Average</u>
Moisture Content (w%)	7.0 - 28.0	16.3
Plastic Limit (w _p %)	14.0 - 18.0	16.0
Liquid Limit (w _L %)	18.5 - 31.0	23.7
Plasticity Index (I _p)	0.5 - 13	
Unit Weight (γ kN/m ³)	22.0 - 22.7	22.4

The Atterberg Limits of this generally cohesive deposit indicate a matrix that falls in the CL-ML zone (Figure 1). A grain size distribution envelope for this material is developed in Figure 2.

Sand and Gravel (Bedding and Backfill Material)

A layer of sand and gravel fill material is present in BH 4 underlying the silt fill deposit. It was encountered at approximate El. 80.3 and is estimated to be 1.0 m in thickness. The sand and gravel is likely to be the bedding and backfill material to an adjacent water main that runs in a north-southerly direction. Its presence is likely in the south approach embankment as well, in the vicinity of the water line.

Laboratory testing on a single sample revealed a material composed largely of sand and gravel, with silt. A moisture content of 13% was measured. An N value of 1 per 30 cm was recorded, indicating the material is in a very loose state.

Silt to Sandy Silt (Glacial Till)

All four boreholes were terminated in a non-cohesive silt to sandy silt glacial till deposit. It was encountered at El. 79.3 at each of the boring locations, 4.9 to 5.2 m below the ground surface. The silt to sandy silt deposit contains trace gravel and cobbles, and given its glacial origin, boulders are likely.

N values obtained during sampling exceed 120 blows per 30 cm, indicating that the deposit is in a very dense state. Grain size distribution analyses revealed a fine grained matrix composed largely of non-plastic silt.

Groundwater Conditions

The groundwater level was established by measuring in the open boreholes. The readings taken at BH's 2 and 4 on the day of the investigation had not stabilized. At BH 2 the groundwater elevation was 80.5 and 83.1 at BH 4.

DISCUSSION AND RECOMMENDATIONS

In order to accommodate the widening of the QEW at the Victoria Avenue Structure, it is proposed to replace the forward slopes at the north and south abutments with retaining walls. The retaining wall proposed at the north abutment is approximately 41.5 m in length and extends beyond the structure by 12 m on either side. Beneath the structure, the retaining wall varies from 3.6 to 4.1 m in height. The retaining wall proposed at the south abutment is approximately 41.0 m and extends beyond the structure by 9.0 m on the west side and extends 13.5 m beyond the structure on the east side and is skewed 10° to the south. The south retaining wall reaches a height of 3.2 to 3.6 m beneath the bridge.

The Victoria Avenue structure has four spans (13-23-23-13) and is approximately 72 m long. The profile elevation of Victoria Avenue is 90.2 at the south end of the structure dipping to El. 89.5 at the north approach. The QEW lies at approximate El. 84.0 along the EB lanes and at El. 83.5 at the WB lanes. The abutment footings of the Victoria Avenue Underpass are perched and founded on short piles to shale bedrock. The north abutment base of pile cap elevation is 86.0 m, the south abutment pile cap base at El 86.6. The pier footings are shallow foundations with base of footing elevations of 80.7 m.

The presence of the water main on the west side of both the north and south abutments poses some difficulties with regards to design and construction. It is anticipated that the conditions encountered at BH 4 exist from the west edge of the abutment to the west end of the retaining wall, given that the existing water line runs beneath the embankment in a N-S direction, 6 to 7 m west of the abutment edge. Its depth is assumed to be approximately El. 80.0. The subsurface material is very soft/very loose and appears to be aggravated by water either leaking from the water main or by groundwater flow within the backfill adjacent the water line. A forcemain is also present at the east end of the north retaining wall. The underground facilities may be adversely affected by the load imposed by the retaining structures if founded on conventional spread footings. Unless there are plans to relocate the underground water lines, the influence of the new load should be checked.

Excavation of the forward slopes beneath the existing abutments will require shoring to construct the retaining walls. Because of the close proximity of the pier and its configuration, accessibility to the site may be difficult using conventional equipment required for a soldier pile/timber lagging type wall. The Foundations group will consult with industry regarding the access issue. An alternative such as soil nailing may be considered under these circumstances, but will require additional fieldwork to confirm the suitability of the backfill material.

Retaining Wall Foundations

Based on the results of the field investigation, it is recommended that the retaining wall design take the form of three separate components, these being west, centre and east. Accordingly, specific foundation recommendations are provided for each.

East Component - North and South Retaining Walls

The East Component can be considered the portion of walls that extends east beyond the existing structure. The east component of the walls may be founded on spread footings on native soil. The south-east footing may be founded at or below El. 82.1, and the north-east footing at or

below El 82.4. The following design values as per OHBDC 3rd apply, assuming 25 mm of deformation and a footing width of 3.0 m:

Factored Bearing Resistance at ULS	300 kPa
Bearing Resistance at SLS	200 kPa

Alternatively, the footings may be founded on a minimum 1.0 m thick compacted Granular A pad, the base of the pad at elevation 82.4 m or lower. Similar design values and assumptions apply.

Care should be taken when excavating near the force main at the east end of the north retaining wall footing. Its precise location and elevation is not known and should be confirmed by the Regional Municipality. This information was not available when a stake-out for the subsurface investigation was carried out.

Centre Component

The Centre Component refers to the portion of the retaining walls that extend beneath the Victoria Avenue structure. Shoring is required to protect the existing structure. For a soldier pile/timber lagging wall, it is recommended that H-piles be partially installed by pre-augering to minimize disturbance to the structure. Pre-augering to bedrock may be necessary if there are installation constraints.

The following design values may be applied for H-Piles on shale bedrock, approximate El. 76.2:

Factored Axial Resistance at ULS	1800 kN
Axial Resistance at SLS	does not apply

West Component

The West Component refers to the portion of the walls extending west beyond the existing structure. Because poor material was encountered at the north-west quadrant of the site and because of the water main present in the north and south embankments, the following recommendations were developed to minimize disturbance to the existing water main.

It is recommended to sub-excavate to a depth of 1.0 m below the proposed footing base for the full length of the west component. The material should be replaced with HL-8 by end-dumping. An additional 1.0 m of HL-8 should then be placed in three compacted lifts of 0.3m thickness. Following compaction, the excess HL-8 may be removed to the elevation of the proposed base of footing.

The following design values apply, assuming a footing width of 3.0 m and a deformation in the order of 50 mm:

Factored Bearing Resistance at ULS	300 kPa
Bearing Resistance at SLS	200 kPa

Again, the precise location and elevation of the water main is not known and should be confirmed by the Regional Municipality.

If 50 mm deformation is not acceptable, or if deep foundations prove more economical, the portion of the retaining walls west of the abutments may be founded on piles to bedrock. Pile installation equipment on site for the shoring wall could be used for the piled foundation work as well.

The design values provided for H-piles on shale bedrock apply. A bedrock elevation of 76.2 may be assumed. Care should be taken to minimize disturbance to the underground water line. This may be facilitated by pre-augering to a depth of 2.0 m below the elevation of the water line before commencing driving.

General Recommendations for Spread Footings

No dewatering concerns are anticipated for the footing excavations. It is expected that any seepage into the excavation can be relieved by sump pumping techniques.

To minimize disturbance to the base of the footing, it is recommended that concrete for the footing be poured within 12 hours of completion of footing excavation. Alternatively, a lean concrete working base 150 mm in thickness should be constructed.

A minimum 1.2 m of earth cover is required for frost protection.

The sliding resistance between the base of the footing and the native ground may be computed using an unfactored friction coefficient of 0.35 ($\delta=20^\circ$). A factor of 0.55 ($\delta=30^\circ$) may be used for a footing on the HL-8 fill.

Lateral Earth Pressure

Backfill to the retaining structures should consist of granular material in accordance with MTO Standard Special Provision 109F03. Computation of earth pressures should be in accordance with Section 6-7.4.2 of the OHBDC, 3rd Edition. Design parameters of the acceptable granular backfill are provided as follows:

	Granular "A"	Granular "B"
Angle of Internal Friction (ϕ)	35°	30°
Unit Weight (kN/m ³)	22.8	21.2

The active earth pressure applies where the structure is yielding and movements within the soil mass are permitted. It is expected that this condition will apply.

Construction Considerations

Articulated joints sufficient to accommodate differential movements will be required to "join" the three components of the north and south retaining walls. The use of a Retained Soil System is recommended for the east and west components of both walls.

Shoring will be required in order to excavate the forward slopes to the structure and to construct the retaining walls. The following parameters are provided for calculation of earth pressures:

<u>Soil Type</u>	<u>Deposit Extent</u>	ϕ	γ
Silt Fill	El. 89.0+/- to 83.0+/-	28°	20kN/m ³

A groundwater elevation of 83.0 m may be assumed for design.

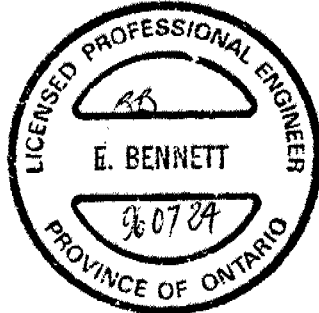
Slope Stability

The existing slopes are stable and it is anticipated that no stability problems will be encountered with the proposed design, provided that slopes of 2H:1V or flatter are maintained. Where fill heights exceed 8.0 m, a 2.0 m wide mid-height berm should be incorporated.

Miscellaneous

The fieldwork for this investigation was carried out on November 27, 1995 under the supervision of B. Bennett, Foundation Engineer and P. Pasqualini, Engineering Trainee.

The report was prepared by B. Bennett, Foundation Engineer and was reviewed by D. Dundas, Senior Foundation Engineer.

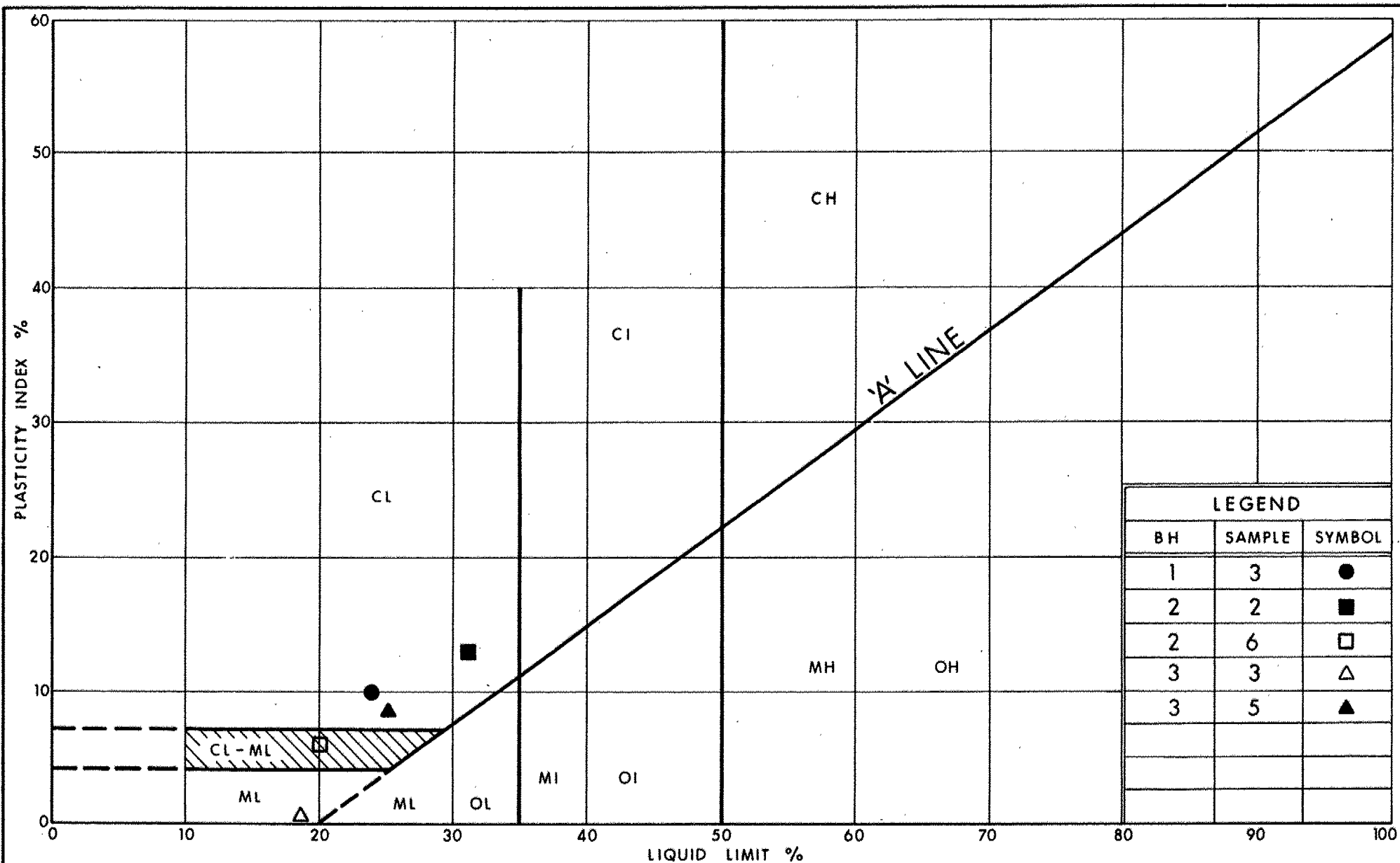


B. Bennett
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APPENDIX



Ontario

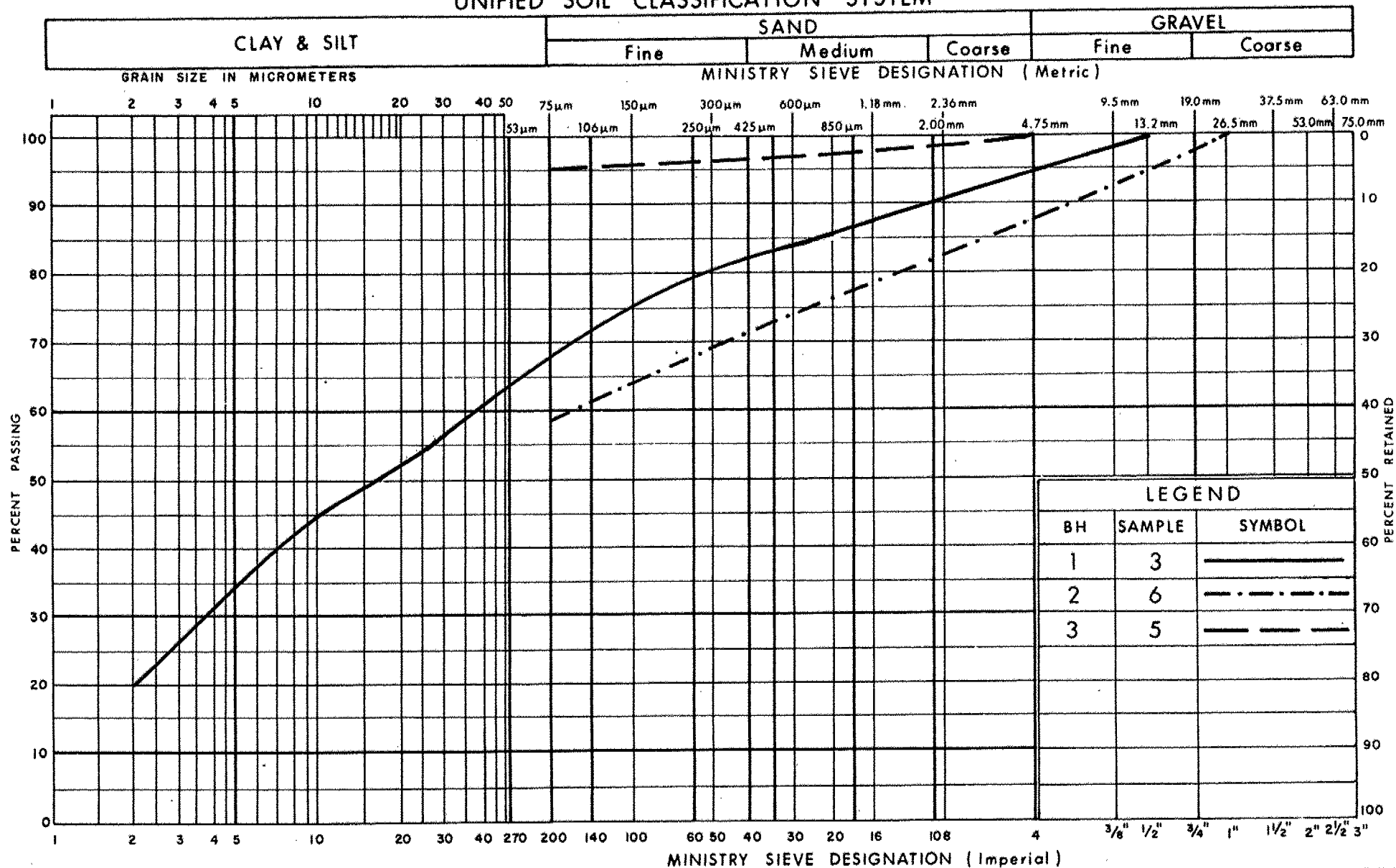
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PLASTICITY CHART CLAYEY SILT TO SILT

FIG No 1

W P 335-89-00

UNIFIED SOIL CLASSIFICATION SYSTEM

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GRAIN SIZE DISTRIBUTION CLAYEY SILT TO SILT

FIG No 2

W P 335 -89-00

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 335-89-00 LOCATION Co-ords: N 4 782 706.0, E 313 308.7 ORIGINATED BY BB
DIST CR HWY QEW BOREHOLE TYPE SS Auger COMPILED BY BB
DATUM Geodetic DATE 95 11 27 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						
								SHEAR STRENGTH kPa						
								○ UNCONFINED + FIELD VANE						
								● QUICK TRIAXIAL × LAB VANE						
84.5	Ground Surface													
0.0	SILT					DRY *	84						22.7	6 25 49 20
	Trace Sand													
	Trace Gravel		1	SS	25									
	Occasional clayey silt zones													
	Brown/Grey													
	Compact													
82.7	(Fill Material)		2	SS	22			83						
1.8														
	Brown													
	Grey	3	SS	20		82								
	CLAYEY SILT to SILT	4	SS	13		81								
	Trace/Some Sand													
	Trace Gravel													
	Stiff to Hard	5	SS	25		80								
	Probable Cobbles	6	SS	64		79								
79.3														
5.2	SANDY SILT													
78.8	Trace Gravel/Cobbles (Glacial Till)	7	SS	107	/23cm								5 26 62 7	
	Very Dense													
5.7	End of Borehole													
	* Dry upon completion													

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 335-89-00 LOCATION Co-ords: N 4 782 707.5 E 313 357.0 ORIGINATED BY BB
 DIST CR HWY QEW BOREHOLE TYPE SS Auger COMPILED BY BB
 DATUM Geodetic DATE 95 11 27 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
84.2	Ground Surface																
0.0	SILT Trace Sand Occasional Clayey Silt zones Compact						84										
83.1	(Fill Material)		1	SS	22												
1.1	Trace Organics						83										
	CLAYEY SILT to SILT																
	Trace Sand		2	SS	10												0 3 (97)
	Brown						82										
	SAND to SILTY SAND Occ. Cohesive seams Very Dense		3	SS	55												0 19 75 6
			4	SS	101		81										
	Some Sand Trace Gravel Grey		5	SS	44		80										
	Sand Till zone																
79.3	Stiff to Hard		6	SS	60	/10cm											13 28 (59)
4.9	SANDY SILT Trace Gravel/Cobbles																
78.7	Very Dense (Glacial Till)		7	SS	70	/13cm	79										
5.5	End of Borehole * Not Stabilized																

RECORD OF BOREHOLE No 3

1 OF 1

METRIC

W.P. 335-89-00 LOCATION Co-ords: N 4 782 777.8, E 313 352.0 ORIGINATED BY PP
 DIST CR HWY QEW BOREHOLE TYPE SS Auger COMPILED BY BB
 DATUM Geodetic DATE 95 11 27 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	WATER CONTENT (%)	UNIT WEIGHT 7 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					
84.5	Ground Surface																
0.0	SILT Trace Sand Occasional Clayey Silt zones Loose (Fill Material)		1	SS	9	DRY *	84										1 5 (94)
82.4			2	SS	9		83										0 4 (96)
2.1	CLAYEY SILT to SILT Trace Sand Stiff to Hard Grey Brown		3	SS	42		82										
			4	SS	19		81										
			5	SS	10		80										
79.3	Some Sand Trace Gravel Probable Cobbles		6	SS	16		79										
5.2	SANDY SILT Trace Gravel/Cobbles Very Dense		7	SS	88 /28cm												
78.2	(Glacial Till)		8	SS	99												
6.3	End of Borehole * Dry upon completion				23cm												

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

W.P. 335-89-00 LOCATION Co-ords: N 4 782 875.8, E 313 309.0 ORIGINATED BY BB
 DIST CR HWY QEW BOREHOLE TYPE SS Auger COMPILED BY BB
 DATUM Geodetic DATE 95 11 27 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W _p	W	W _L		
84.5	Ground Surface																
0.0	SILT Trace/Some Organics Trace Sand Trace Gravel Occasional clayey silt zones Very Loose to Compact (Fill Material) (Backfill for Water Main)		1	SS	22		84										
			2	SS	4		83										8 11 68 13
			3	SS	0 /46cm		82										
80.3			4	SS	5		81										
4.2	SAND and GRAVEL Very Loose		5	SS	1 /30cm		80										41 37 18 4
79.3	(Bedding and Backfill Mat'l for Water Main)		6	SS	60 /8cm		79										9 17 (74)
5.2	SANDY SILT Trace Gravel/Cobbles Very Dense		7	SS	60 /15cm												
78.3	(Glacial Till)																
6.2	End of Borehole * Not Stabilized																

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

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

SS SPLIT SPOON	TP THINWALL PISTON
WS WASH SAMPLE	OS OSTERBERG SAMPLE
ST SLOTTED TUBE SAMPLE	RC ROCK CORE
BS BLOCK SAMPLE	PH TW ADVANCED HYDRAULICALLY
CS CHUNK SAMPLE	PM TW ADVANCED MANUALLY
TW THINWALL OPEN	FS FOIL SAMPLE

STRESS AND STRAIN

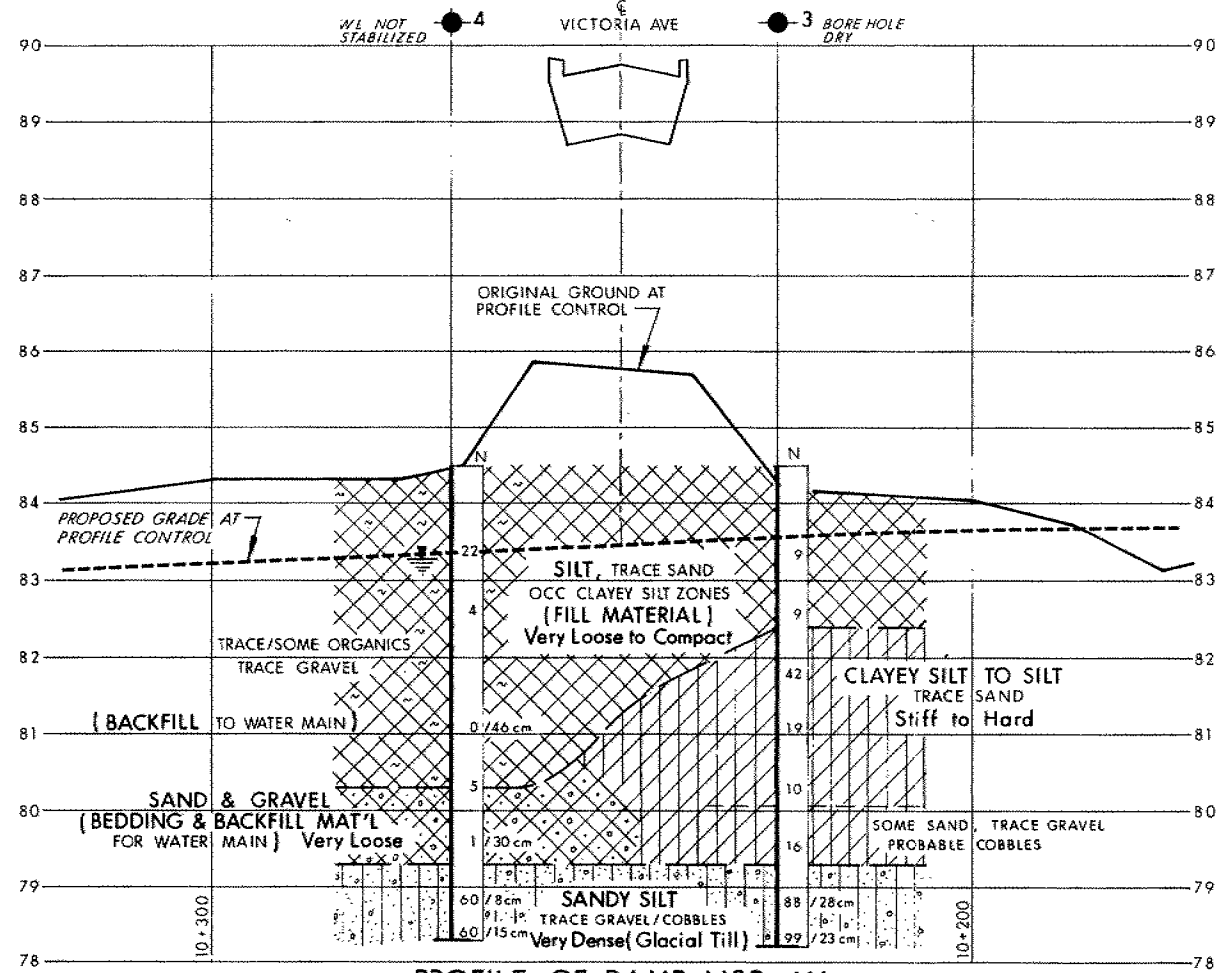
u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

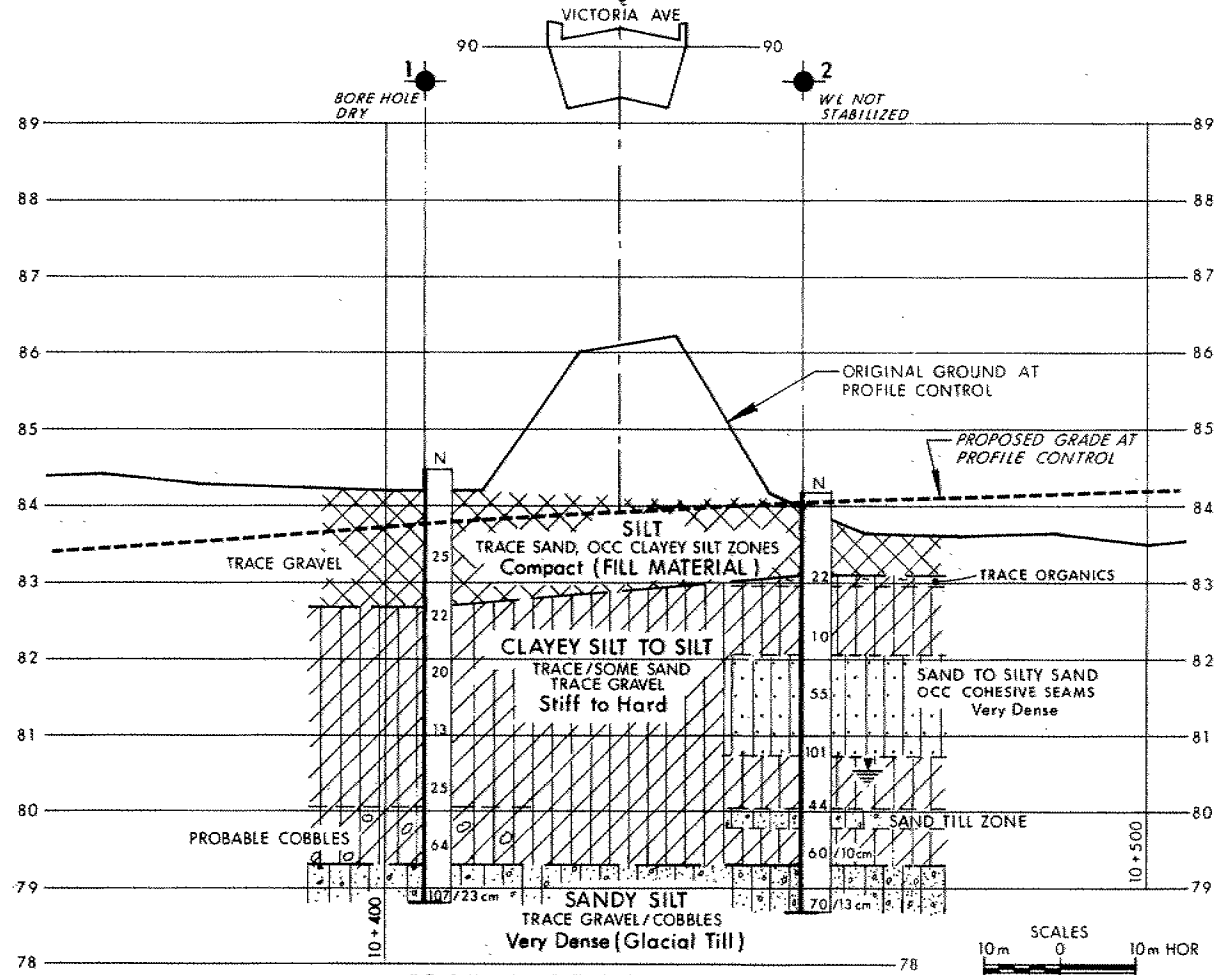
m_v	kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
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

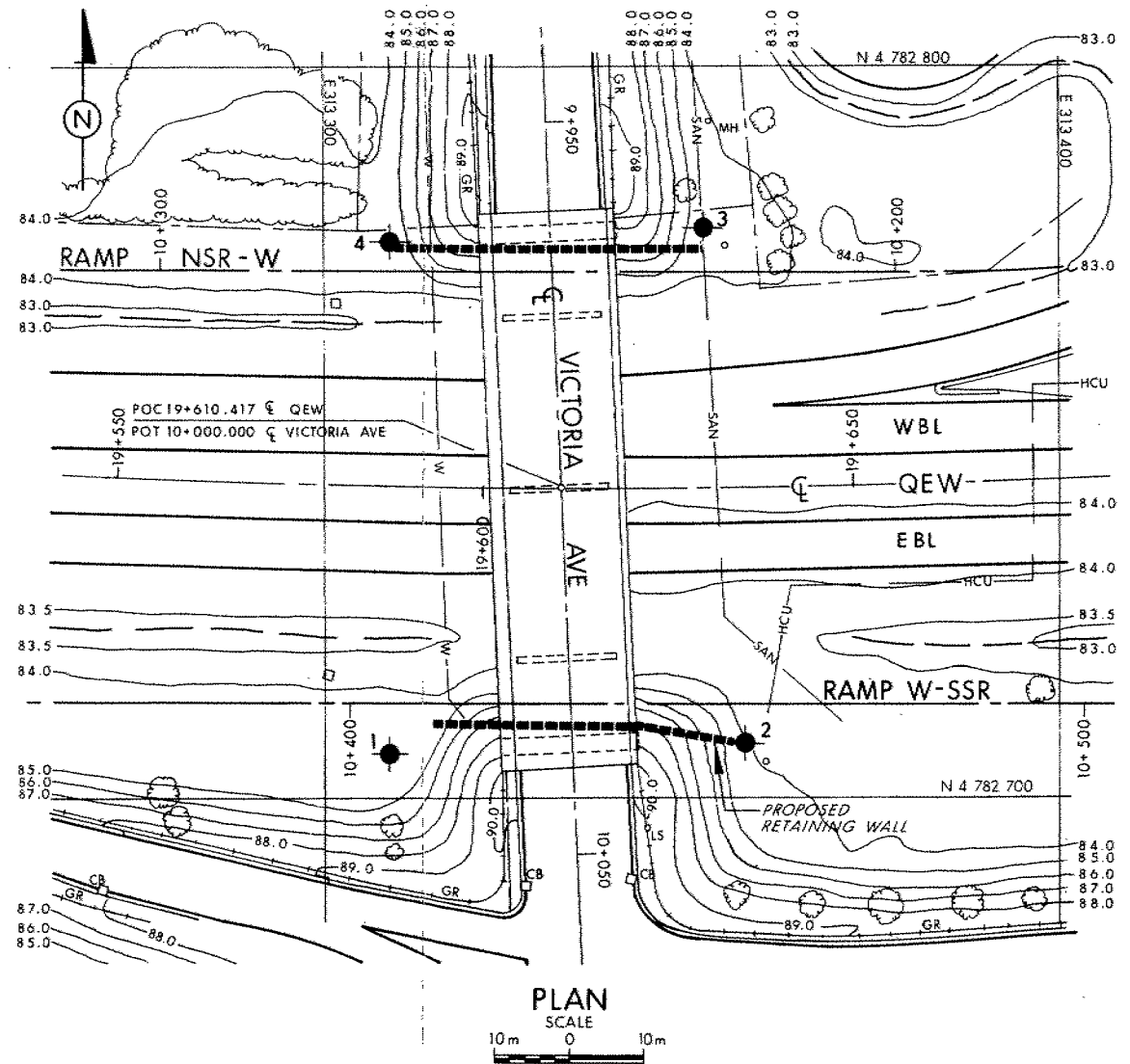
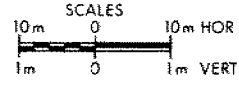
P_s	kg/m ³	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kn/m ³	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m ³	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kn/m ³	UNIT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



PROFILE OF RAMP NSR - W



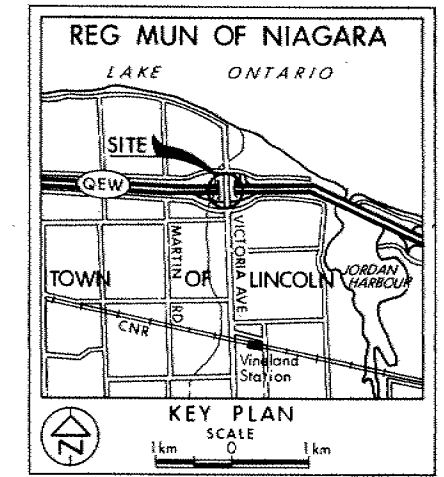
PROFILE OF RAMP W - SSR



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

CONT No
WP No 335-89-00

RETAINING WALLS
AT VICTORIA AVE
BORE HOLE LOCATIONS & SOIL STRATA



- 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 1995 11

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	84.5	4 782 706.0	313 308.7
2	84.2	4 782 707.5	313 357.0
3	84.5	4 782 777.8	313 352.0
4	84.5	4 782 875.8	313 309.0

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

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



REV	DATE	BY	DESCRIPTION

Geocres No 30M3-207

HWY No QEW	CHECKED	DATE 1996 07 02	DIST CR
SUBMD BB	CHECKED		SITE
DRAWN RS	CHECKED		DWG 3358900-A

m e m o r a n d u m



To: V. Boehnke
Head, Structural Section
Central Region

November 27, 1996

Attn: N. Potak
Sr. Structural Engineer

From: Pavements and Foundations Section
Room 315, Central Building

Re: Horizontal Subgrade Reaction Coefficients
QEW Widening at Victoria Avenue
WP 335-89-00

Please find following the coefficients of horizontal subgrade reaction for the proposed retaining structures at Victoria Avenue.

North Abutment

El. 84 - 82	Silt, Loose	$k_h = 7\,000 \text{ kN/m}^3$
El. 82 - 79	Clayey Silt to Silt, Stiff	$k_h = 21\,000 \text{ kN/m}^3$
El. 79 - 76	Sandy Silt Till, Very Dense	$k_h = 150\,000 \text{ kN/m}^3$
Below El. 76	Shale Bedrock	Assume same as Till

South Abutment

El. 84 - 83	Silt, Compact	$k_h = 10\,000 \text{ kN/m}^3$
El. 83 - 79	Clayey Silt to Silt, Stiff	$k_h = 21\,000 \text{ kN/m}^3$
El. 79 - 76	Sandy Silt Till, Very Dense	$k_h = 150\,000 \text{ kN/m}^3$
Below El. 76	Shale Bedrock	Assume same as Till

I apologize for the delay in providing the values to you. Your request included the design assumptions/values for the rock anchor alternative. I will provide those values to you next week. If there are any questions regarding the above, please advise.

Betty Bennett, P.Eng.
Foundation Engineer
(-4333)

e-mail 20 pm