

GEOCRES No:
31F-114

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 451-90-02

DIST 9

HWY 17

STR SITE

Proposed Hwy. 17 Realignment and
Regional Road 20

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Preliminary
FOUNDATION INVESTIGATION REPORT
For
Proposed Hwy. 17 Realignment and Regional Road 20
W.P. 451-90-02
District 9, Ottawa

INTRODUCTION

This report summarizes the results of a preliminary foundation investigation conducted between 91 10 17 and 91 10 18 at the aforementioned site. Two sampled boreholes were advanced as part of this project by means of 82 mm I.D. Hollow stem augers. These boreholes were sampled down to refusal at depths of 23.5 m and 29.5 m. The results of this investigation are included in this report.

SITE DESCRIPTION

The site is located approximately 1-2 km south of existing Hwy. 17 along Regional Road 20, Township of Fitzroy, Regional Municipality of Ottawa - Carleton. The area consists of farmers fields to the east and west.

Regional Road 20 is a narrow paved two lane road with drainage ditches adjacent to both shoulders. The terrain surrounding the site is generally flat to gently rolling with short wild grasslands.

Geologically the site is located within the physiographic region known as the "Ottawa Valley Clay Plains". This region, in the vicinity of the site is characterized by an extensive stratum of sensitive clay. The clay, known locally as "Leda Clay", was deposited in the geological past in the Champlain Sea. This stratum is underlain by limestone bedrock of the Trenton and Black River groups, Ordovician period.

INVESTIGATION PROCEDURES

Soil data and inherent properties were obtained by in situ and laboratory testing. The procedures employed are discussed below.

FIELD INVESTIGATION

The fieldwork for the investigation was carried out between 91 10 17 and 91 10 18 and consisted of two sampled boreholes which were advanced to depths of 23.5 and 29.5 m. The boreholes were located to the east of Regional Road 20, in the general area of proposed new alignment for Hwy 17. No borehole was put down to the west of Regional Road 20 due to access problems.

The boreholes were advanced using conventional hollow stem augering techniques.

A track mounted continuous flight auger drill rig was employed for the operation. In general, subsoil samples were retrieved at 0.7 m intervals within the top 6 m depth and at 1.5 m to 3.05 m intervals thereafter. Disturbed subsoil samples were retrieved by a split spoon sampler in accordance with the Standard Penetration Test (ASTM D1586). Relatively undisturbed samples were randomly retrieved using thin walled shelby tube samplers in accordance with Standard Practice (ASTM D1587). In situ vane tests were also conducted in sequence between the aforementioned sampling intervals to determine the undisturbed and remoulded undrained shear strengths of soil. The test was conducted employing the Standard MTO 'N' vane.

All subsoil samples were identified in the field and returned to the laboratory for further examination and applicable testing.

Water levels were monitored throughout the duration of the investigation in open boreholes and open standpipes. All boreholes were backfilled upon completion of the fieldwork.

Survey information related to the location and elevation of boreholes was provided by the Eastern Region, Surveys and Plans Section. The natural ground surface is at El. 109.1 m to 109.3 m.

LABORATORY ANALYSIS

The following laboratory tests were carried out on select soil samples.

- 1) Atterberg Limit Test
- 2) Grain Size Distribution
- 3) Unit Weights
- 4) Natural Moisture Contents

Laboratory Test Results are given in the following section of this report and are illustrated on figures and record of borehole sheets included in the Appendix.

SUBSURFACE CONDITIONS

The predominant soil stratum encountered in both boreholes consisted of clayey silt to silty clay, extending from the ground surface to the end of boreholes. A brief description of this stratum is given below.

The locations of borings are shown on Dwg. No. 4519002-A in the attached Appendix. The field and laboratory test results are plotted on the Record of Borehole sheets also included in the Appendix of this report.

Clayey Silt to Silty Clay

A clayey silt to silty clay stratum was encountered in both boreholes extending from the surface down to depths of 23.5 m and 29.5 m, where refusal to further advance by augering was encountered. The top 0.5 m to 1.0 m of this layer contained some organics.

Results of Grain Size Distribution tests carried out on select samples are shown on Figure 1 in the Appendix, in an envelope form. The results indicate that the material contains a large percentage of silts and clays, with only 0-10% sand sized particles.

The results from the field and laboratory tests performed on this deposit are summarized as follows:

	<u>Range</u>	<u>No. of Tests</u>
Natural Moisture Content (w)	14-84 %	14
Liquid Limit (w_L)	27-44 %	10
Plastic Limit (w_p)	16-22 %	10
Plasticity Index (I_p)	10-12	10
Sensitivity	3-16	26
Undrained Shear Strength C_u (kPa)		
Field vane shear tests	11-88	26
Laboratory UU (triaxial) tests	38-43	2
Unit weights (kN/m^3) γ	15-20	8

The natural moisture contents varied between 14 and 84 percent, but were generally in the 29 to 51 range. The natural moisture contents are generally close to or slightly greater than the liquid limit.

From the Plasticity Chart (Figure 2), the layer can be classified as a clayey silt to silty clay of low to intermediate plasticity.

The field vane shear strengths varied between about 50 kPa and 88 kPa in the upper 2 m to 3 m, gradually decreasing to about 11 kPa to 25 kPa at about 4 m to 6 m. Below this depth, strengths gradually increase with depth reaching a value of about 50 kPa to 80 kPa at about 18 m to 21 m depth. Based on the above, the consistency of this deposit is considered to vary between soft and stiff.

The results of the four consolidation tests carried out on select samples of this deposit indicate void ratios of 1.20 to 2.54 and compression indices of 0.46 to 1.77. The preconsolidation pressures obtained range from 66 to 170 kPa and are generally equal to or higher than the existing effective overburden pressures,

indicating that the material is a normally to over-consolidated clay.

GROUNDWATER

Observations of the groundwater level was carried out by measuring the water levels in open boreholes and standpipes during the course of the investigation. Groundwater levels were encountered at depths of 2.0 m and 8.8 m below grade.

Groundwater levels in general, are subject to seasonal fluctuations and hence can vary from values given in this report.

DISCUSSION AND RECOMMENDATIONS

It is proposed to construct a structure to carry the EB and WB lanes of Regional Road 20 over the proposed realigned and widened Hwy. 17. At this time the structure and approach fill details are not known. For the purposes of this report, we have assumed that the maximum height of the approach fills would be about 8 m above the existing grade. Some general recommendations regarding the design and construction of structure foundations and approach embankments are given below. When further details concerning the proposed construction at this site are known, this office should be contacted for a review of the general recommendations given herein below.

A plan illustrating borehole and site location are shown on Dwg. No. 4519002-A included in the Appendix.

1. Structure Foundations

The predominant soil stratum at the site consists of a soft to stiff clayey silt to silty clay. This stratum is probably underlain by bedrock.

The presence of a relatively weak clayey silt to silty clay extending to 23.5 m and 29.5 m below grade, precludes the use of shallow spread footings located on or within this deposit or perched within the compacted granular fill placed above the layer. It is therefore recommended that all foundations are supported on steel H-piles resting on bedrock or any other competent end bearing stratum.

For the purpose of the O.H.B.D.C., a factored axial bearing capacity at ULS of 1600 kN and an SLS Type II bearing capacity of 1150 kN shall be used for 310 x 110 steel H piles driven to bedrock. For preliminary estimating purposes, the length of piles may be taken as 23.5 m to 29 m. It should, however, be noted that bedrock was not established during this investigation and, therefore, piles may terminate on or within a glacial till or similar deposit, at about the depths mentioned above. Should this be the case, then the pile installation should be controlled by the Hiley formula.

With the construction of the approach embankments and the resulting settlements due to the consolidation of the foundation soils, the piles at the abutments may be subjected to some downdrag forces. For preliminary design purposes 1400 kN and 1000 kN shall be used for factored ULS and SLS capacities for a 310 x 110 steel H pile at the abutment. Alternatively, consideration may also be given to advance construction of the approach embankments to reduce the downdrag forces. These aspects will be discussed in more details by this office in the future.

Use of standard pile tips to facilitate driving of piles without damage, use of batter piles to resist lateral forces and provision of 1.8 m earth cover for pile caps for frost protection etc. should be adhered to.

Similarly, lateral earth pressures on structures should be computed using appropriate earth pressure coefficients for flexible abutments and at rest earth pressures for rigid abutments.

2. Approach Fills

The stability of the slopes was analyzed using a in-house computer program based on the limit equilibrium method of stability developed by Sarma (MTO slope). A minimum factor of safety of 1.3 was incorporated for the analysis. Based on the above analysis it is recommended that approach fills up to 4.5 m are stable utilizing 2H:1V slopes. For fills of up to 8 m a berm width of 20 m would have to be utilized. The results of the analysis are shown in Figure 3.

Alternatively, consideration may be given to utilizing lightweight fills. The maximum height of embankment at 2H:1V slope would be 5.5 m with a lightweight fill unit weight of 15.0 kN/m³.

It is estimated that the consolidation settlement of the foundation soils will range between 0.7 m for a 5 m high fill to about 1.6 m for a 8 m high fill. The corresponding settlements would be about 0.45 m and 0.95 m if lightweight fills are used. These values are considered excessive. Therefore consideration should be given to advance fill placement so that the post construction settlement would be within acceptable limits.

3. Construction Considerations

Existing ground is not considered trafficable for heavy construction equipment, such as pile driving rigs, concrete trucks. Access and haul roads would be required.

No dewatering problems are anticipated due to the presence of relatively low groundwater level and the cohesive nature of the overburden.

Temporary excavations to depths of 2 m or less below grade may be carried out using 1H:1V slope, provided the excavated materials are not stockpiled near the crest of the slope. Under no circumstances should construction traffic be allowed on the excavated base, especially if the base is below or in close proximity to the groundwater level.

CLOSING REMARKS

Recommendations given in this report are to be regarded as preliminary only, and as such are subject to revision when and if new information becomes available. It will probably be necessary to carry out additional field investigation when the final design details are available.

MISCELLANEOUS

The fieldwork for this report was supervised by M. Michalek, Junior Foundation Engineer, and A. Hilderbrand, Engineering Student. The equipment used was owned and operated by Johnston Drilling Ltd.

This report was prepared by M. Michalek and B. Iyer, Senior Foundation Engineer and reviewed by M. Devata, Chief Foundation Engineer.



M. Michalek
Junior Foundation Engineer

M. Devata, P.Eng.
Chief Foundation Engineer

APPENDIX

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

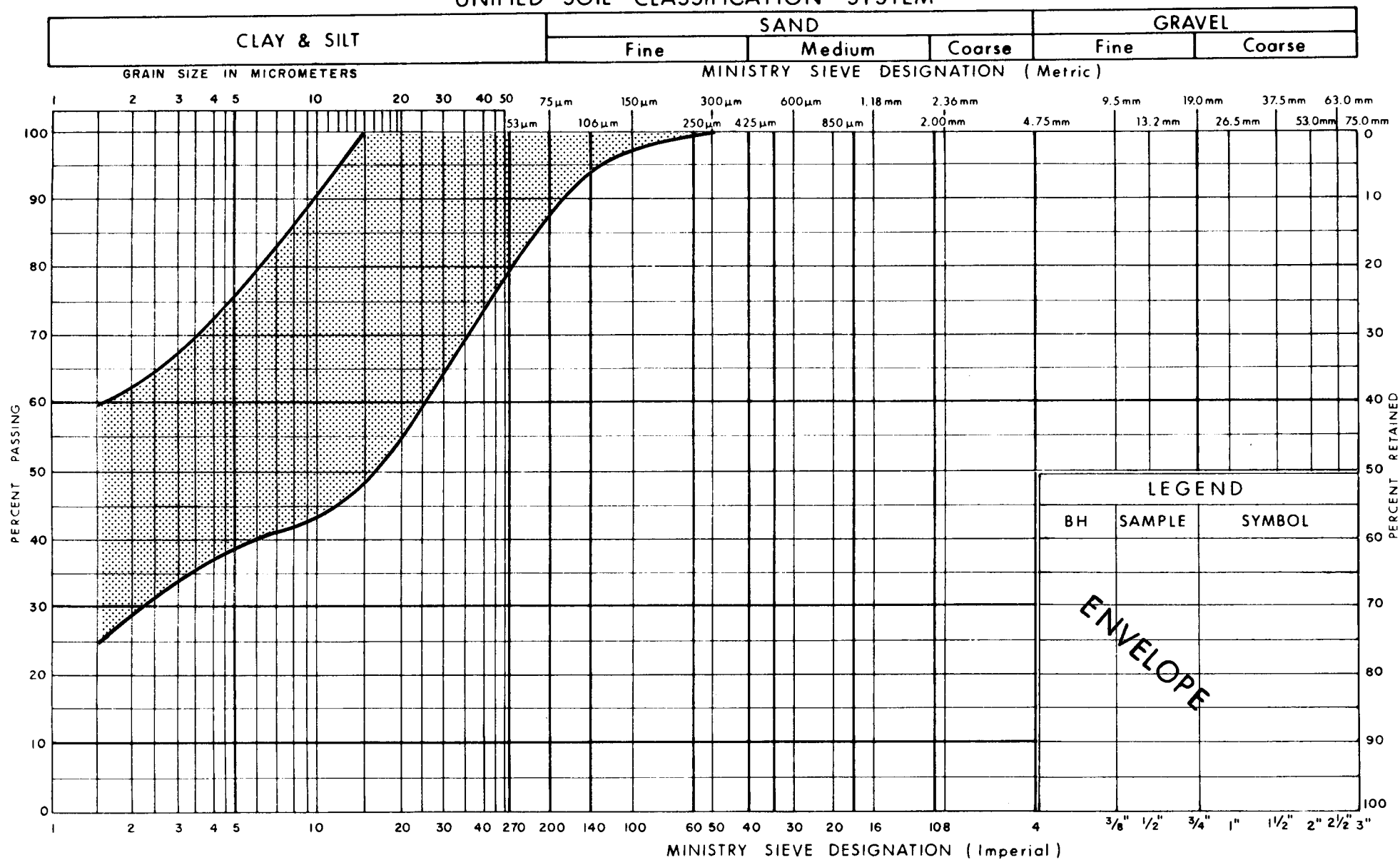
MECHANICAL PROPERTIES OF SOIL

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'_{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						

UNIFIED SOIL CLASSIFICATION SYSTEM

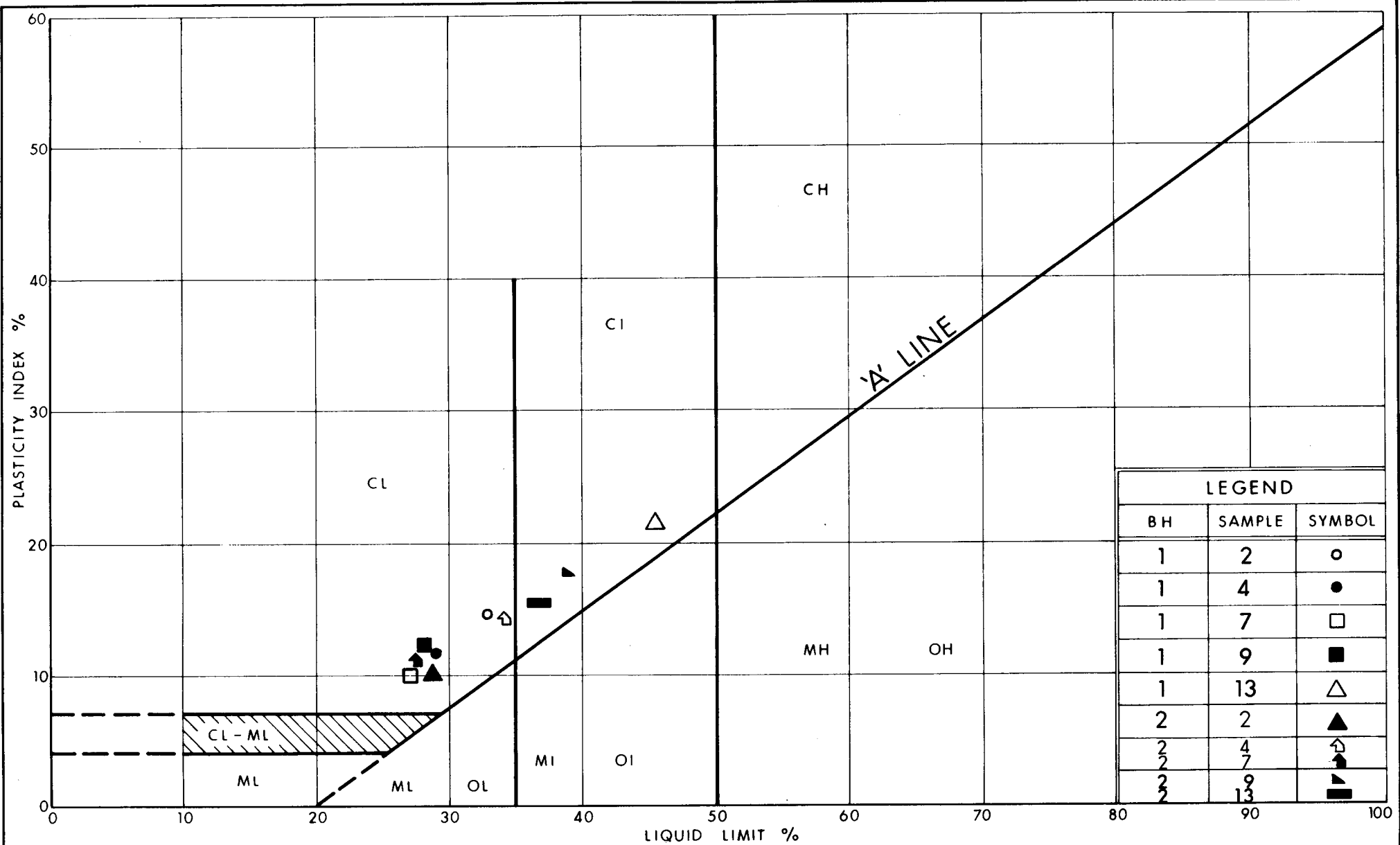


Ministry of
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GRAIN SIZE DISTRIBUTION CLAYEY SILT TO SILTY CLAY

FIG No 1

W P 451-90-02



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Ontario

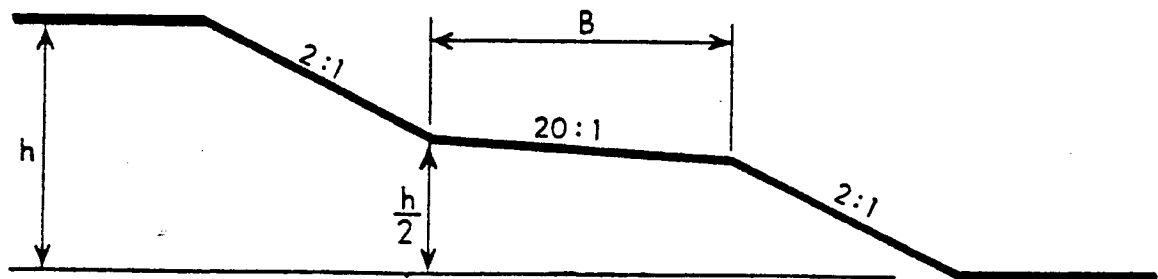
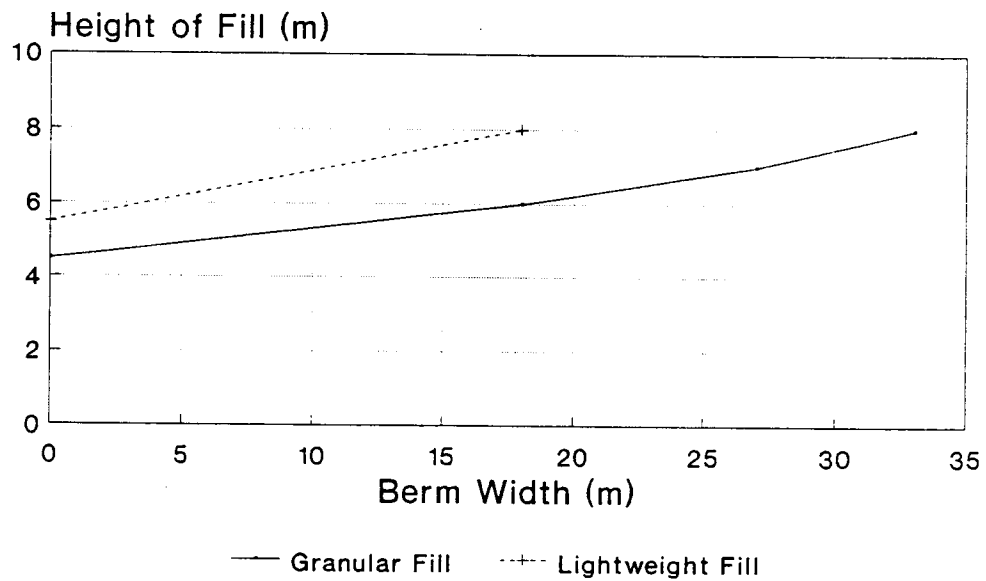
PLASTICITY CHART CLAYEY SILT TO SILTY CLAY

FIG No 2

W P 451-90-02

W.P. 451-90-02

Regional Road 20/ Hwy 17



h = Height of Fill (m)

B = Berm width (m)

Figure - 3

RECORD OF BOREHOLE No 1

1 OF 1 METRIC

W.P. 451-90-02 LOCATION Coords: N 5 024 612.7, E 325 558.8 ORIGINATED BY M.M.
 DIST 9 HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY M.M.
 DATUM Geodetic DATE 91 10 17 - 91 10 18 CHECKED BY B.J.

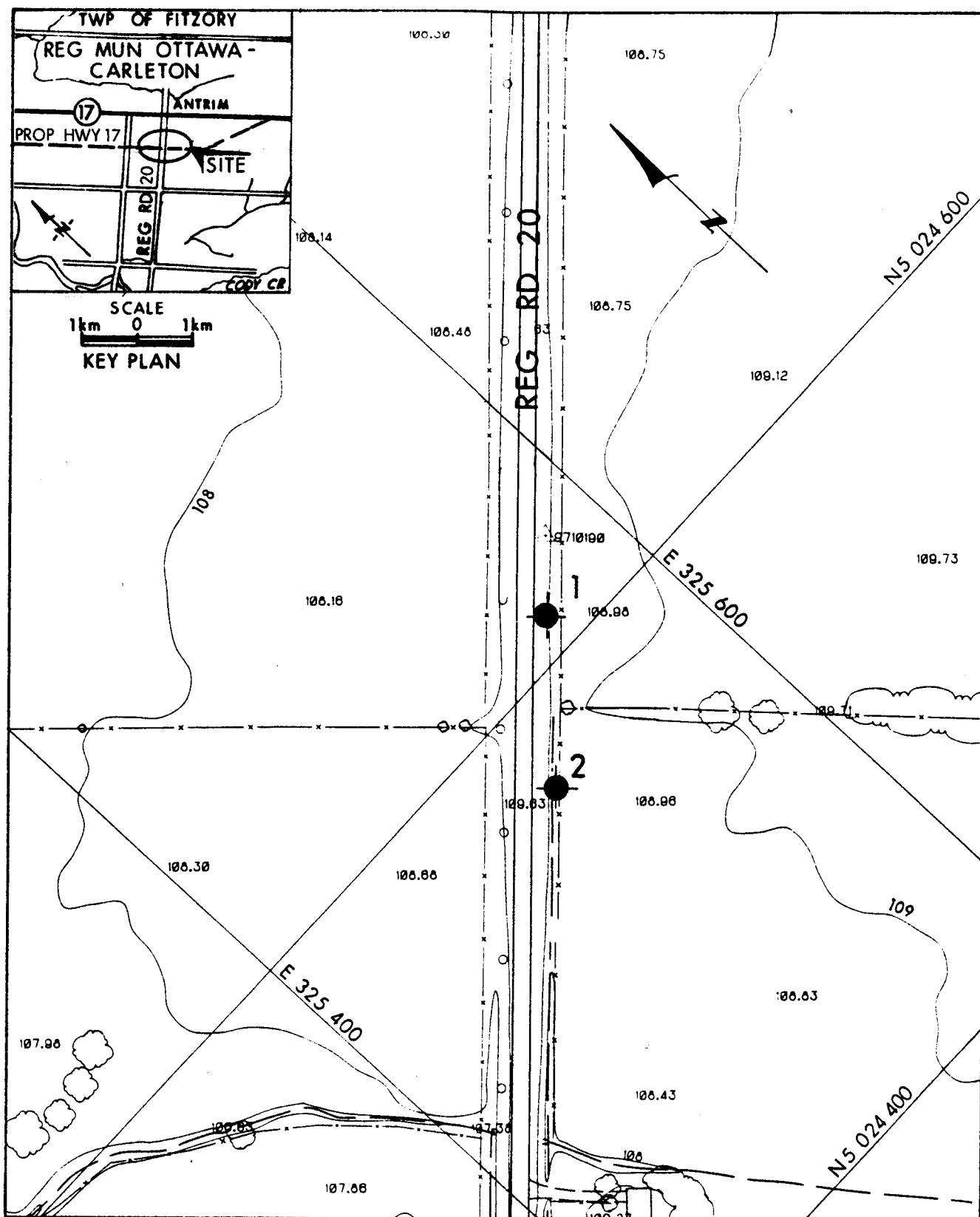
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100							W _P	W	W _L
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
							20 40 60 80 100					WATER CONTENT (%) 20 40 60					
109.3	Ground Surface																
0.0																	
	Organics		1	SS	5		108						18.1	0 6 60 34			
	Stiff		2	SS	3												
			3	SS	2												
	Brown		4	TW	PH		106						18.8				
	Grey		5	SS	0												
			6	TW	PH		104						17.9				
	Soft		7	SS	0												
					/46cm		102										
			8	TW	PH		100										
			9	SS	2												
					/46cm		98						18.1				
	Clayey Silt to		10	TW	PM												
			11	SS	3												
	Silty Clay						96										
	Firm to Stiff		12	TW	PM		94										
							92										
			13	SS	3		90										
					/46cm												
			14	TW	PM		88										
							86										
			15	SS	3		84										
							82										
			16	TW	PM		80										
79.8	91 10 18 * GROUND WATER CONDITIONS																
	PIEZO. NO.																
	GROUND WATER ELEVATION (Metres)																
29.5	End of Borehole																
	1																
	107.3																
	• Probable Bedrock																

RECORD OF BOREHOLE No 2

1 OF 1 METRIC

W.P. 451-90-02 LOCATION Coords: N 5 024 569.3, E 325 510.7 ORIGINATED BY M.M.
 DIST 9 HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY M.M.
 DATUM Geodetic DATE 91 10 17 CHECKED BY B.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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								20	40						
109.1	Ground Surface														
0.0															
	Organics		1	SS	6		108						20.0	0 2 73 25	
	Stiff		2	SS	2										
	Brown		3	SS	3										
	Grey		4	TW	PM		106						18.2		
	Soft		5	SS	1										
			6	TW	PM		104						14.8		
			7	SS	0		102							0 2 63 35	
			8	TW	PM		100								
	Clayey Silt to		9	SS	0		98						16.7		
	Silty Clay		10	TW	PM		96								
	Firm to Stiff		11	SS	0		94								
			12	TW	PM		92								
			13	SS	0		90							0 0 58 42	
			14	TW	PM		88								
85.6							86								
23.5	End of Borehole														
91 10 17 * GROUND WATER CONDITIONS															
PIEZO. NO.		GROUND WATER ELEVATION (Metres)													
1		100.3													



LEGEND

● BOREHOLE

PLAN SCALE

40m 0 40m

NOTE

FOR SUBSOIL INFORMATION REFER
TO RECORD OF BOREHOLE SHEETS

WP 451-90-02
Dwg No 4519002-A