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GEOCRES No. 40I12-22

DIST. 2 REGION

W.P. No. 37-69-01/02

CONT. No. 87-14

W. O. No.

STR. SITE No. 19-413

HWY. No. 2

LOCATION NEWBIGGEN CREEK

(0.8 KM EAST OF HWY 80)

No of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

FOUNDATION INVESTIGATION REPORT

CONTRACT N087 - 14



Ministry of
Transportation and
Communications

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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/0.3m)	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						

Foundation Investigation Report
For
Newbiggen Creek Crossing
W.P. 37-69-02, Site 19-98-413
Hwy. #2, District #2, (London)

Introduction

This report contains the results of the Foundation Investigation carried out at the aforementioned site between 85 01 07 and 85 01 11. The fieldwork consisted of two sampled boreholes and four dynamic cone penetration tests. The borings were advanced by a continuous flight auger machine mounted on an all-terrain vehicle and equipped with hollow stem augers and NX casings.

Site Description

The site is located approximately 0.8 km east of Jct. Hwy. #2 and Hwy. #80 on Hwy. #2, at Newbiggen Creek. The surrounding terrain with the exception of the creek gully, is gently rolling and bare. Physiographically the site is located in a region referred to as the Ekfrid Clay Plain.

Subsurface Conditions

General

The types of till-like stratum (cohesive and non-cohesive) were encountered at this location. Both deposits are of glacial origin. The boundary between these deposits, together with the obtained field and laboratory test results are shown on the Record of Borehole Sheets contained in the Appendix of this report. The stratigraphical sections shown on Drawing No. 2 of the Contract Documents are based upon this information. A description of the difference strata encountered is given below.

Heterogeneous Mixture of Silty Clay, Sand and Gravel

This deposit at the boring locations was observed to extend from the original ground level to approx. El. 181 - 182. The material consists mainly of a heterogeneous mixture of silty clay, sand and gravel (glacial till). The matrix of this till is basically cohesive in nature - i.e. silty clay binding coarser particles.

Atterberg Limit Tests carried out on samples obtained within this deposit, indicate that in general the material is inorganic and of low to medium plasticity. The corresponding natural moisture content in most cases being at or just slightly above the plastic limit. A plot of plasticity index versus liquid limit (Figure #1) shows the point to fall within the vicinity of the dividing line between the CL and CI zones.

Physical properties of the material as determined from laboratory tests are as follows:

	<u>Range</u>
Natural Moisture Content (%)	19-27
Liquid Limit (%)	32-45
Plastic Limit (%)	18-23

The results of the grain-size distribution tests are shown in an envelope form on Figure #2 of the Appendix.

Standard penetration tests carried out within the deposit gave 'N' values (apart from the frost affected zone) to range from 5 to 42 blows per 30 cm.

The consistency of the overall deposit varies from firm to hard.

**Heterogeneous Mixture of Boulders,
Cobbles, Gravel, Sand, Silt and Clay**

A second deposit of glacial till was encountered at El. 181-182 at both borehole locations. The lower boundary was not determined, since the borings were terminated within this deposit but were found to extend for a minimum distance of about 3 metres. Due to the bouldery nature of the material the hollow stem augers were not able to penetrate the deposit. Drilling with diamond tools and tri-cone bits were required to advance the borings. The material in the deposit is basically of a non-cohesive nature. The particle sizes range from clay to boulders. Occasional silty clay layers were also encountered. The natural moisture content was found to be between 5 and 11%.

Standard penetration tests carried out within the deposit gave 'N' values over 100 blows per 30 cm. In most cases 100 blows were required to advance the split-spoon sampler for only a few centimetres. The denseness of the overall deposit may be described as very dense.

Groundwater Conditions

The observed groundwater level was found to be at El. 202.3 at both sampled boring locations at the time of the field investigation.



P. Payer
P. Payer, P. Eng.
Sr. Foundations Engineer

K. G. Selby

K.G. Selby, P. Eng.
Chief Foundations Engineer
(West)

APPENDIX

RECORD OF BOREHOLE No 2

METRIC

W P 37-69-02 LOCATION Sta. 10 + 796A OS 7.6 m RT ORIGINATED BY MJK
 DIST 2 HWY 2 BOREHOLE TYPE Dynamic Cone Penetration Test Only COMPILED BY MJK
 DATUM Geodetic DATE 85 01 11 CHECKED BY

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								
207.7	Ground Level												
0.0	Probably Glacial Till						206						
203.7							204						
4.0	End of Cone Test												

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 1

METRIC

W P 37-69-02 LOCATION Sta. 10 + 819.0 O/S 16.6 m RT ORIGINATED BY MJK
 DIST 2 HWY 2 BOREHOLE TYPE H.S. Auger and Dynamic Cone Penetration COMPILED BY MJK
 DATUM Geodetic DATE 85 01 09-10 CHECKED BY [Signature]

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 20 40 60 80 100	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
203.8	Ground Level												
0.0			1	SS	3								0 39 40 21
			2	SS	5								
			3	SS	11								
			4	SS	11								
			5	SS	14								0 10 45 45
			6	TW	PH								
			7	SS	13								
			8	SS	13								
			9	SS	19								
			10	SS	18								1 7 46 46
			11	SS	17								
			12	SS	18								
			13	SS	20								2 10 46 42
			14	SS	23								
			15	SS	42								
			16	SS	19								
181.5													
22.3													
			17	SS	117								3 29 45 23
			18	SS	100/	10 cm							
			19	SS	100/	5 cm							
175.1													
28.7	End of Borehole												

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 3

METRIC

W P 37-69-02 LOCATION Sta. 10 + 826.1 O/S 13.9 m LT ORIGINATED BY MJK
DIST 2 HWY 2 BOREHOLE TYPE Dynamic Cone Penetration COMPILED BY MJK
DATUM Geodetic DATE 85 01 11 CHECKED BY

[illegible]

⁺3, x⁵: Numbers refer to Sensitivity

20
15 ϕ 5 (%) STRAIN AT FAILURE
10

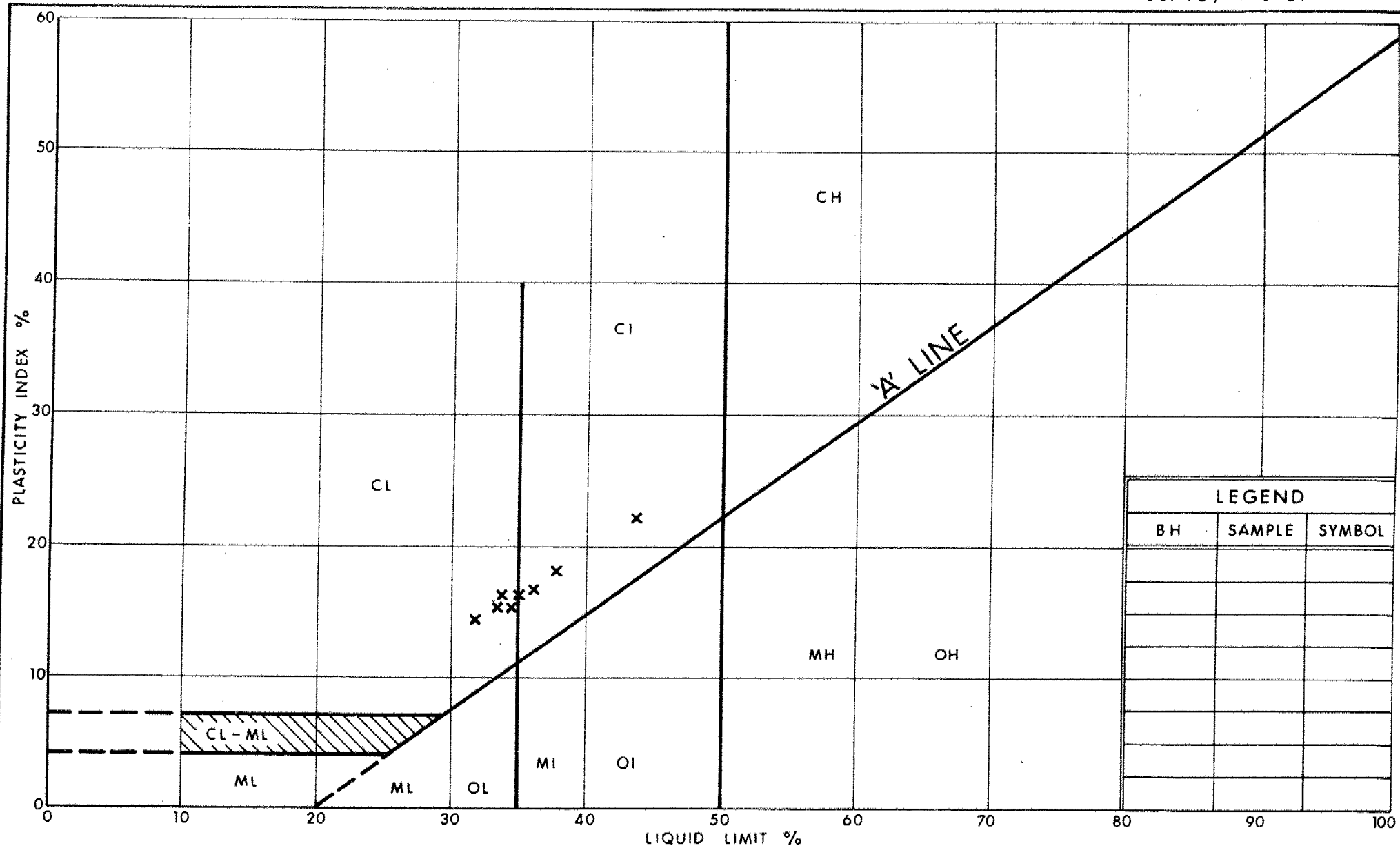
VIRIL REVEALS THE FUTURE OF SOIL EXPLORATION

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	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPo					
202.8	Ground Level						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	10 20 30					GR SA SI

Depth (m)	Soil Description	Sample No.	Soil Type	Grain Size (mm)	Water Content (%)	Shrinkage (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
0.0	Heterogeneous Mixture of Silty Clay Sand and Gravel Firm to Hard Glacial Till	1	SS	6					
		2	SS	14					
		3	SS	16					
		4	SS	11					
		5	SS	14					
		6	SS	14					
		7	SS	12					
		8	SS	21					
		9	SS	16					
		10	SS	19					
		11	SS	19					
		12	SS	29					
		13	SS	29					
		14	SS	34					
		15	SS	22					
182.1	Heterogeneous Mixture of Boulders, Cobbles, Gravel, Sand, Silt and Clay Occ. Silty Clay Layers Very Dense Glacial Till	16	SS	100	1 cm				
20.7		17	RC						
		18	SS	100	30 cm				
178.9		19	SS	100	14 cm				
23.9	End of Borehole								

+3, x5: Numbers refer to Sensitivity



LEGEND		
BH	SAMPLE	SYMBOL



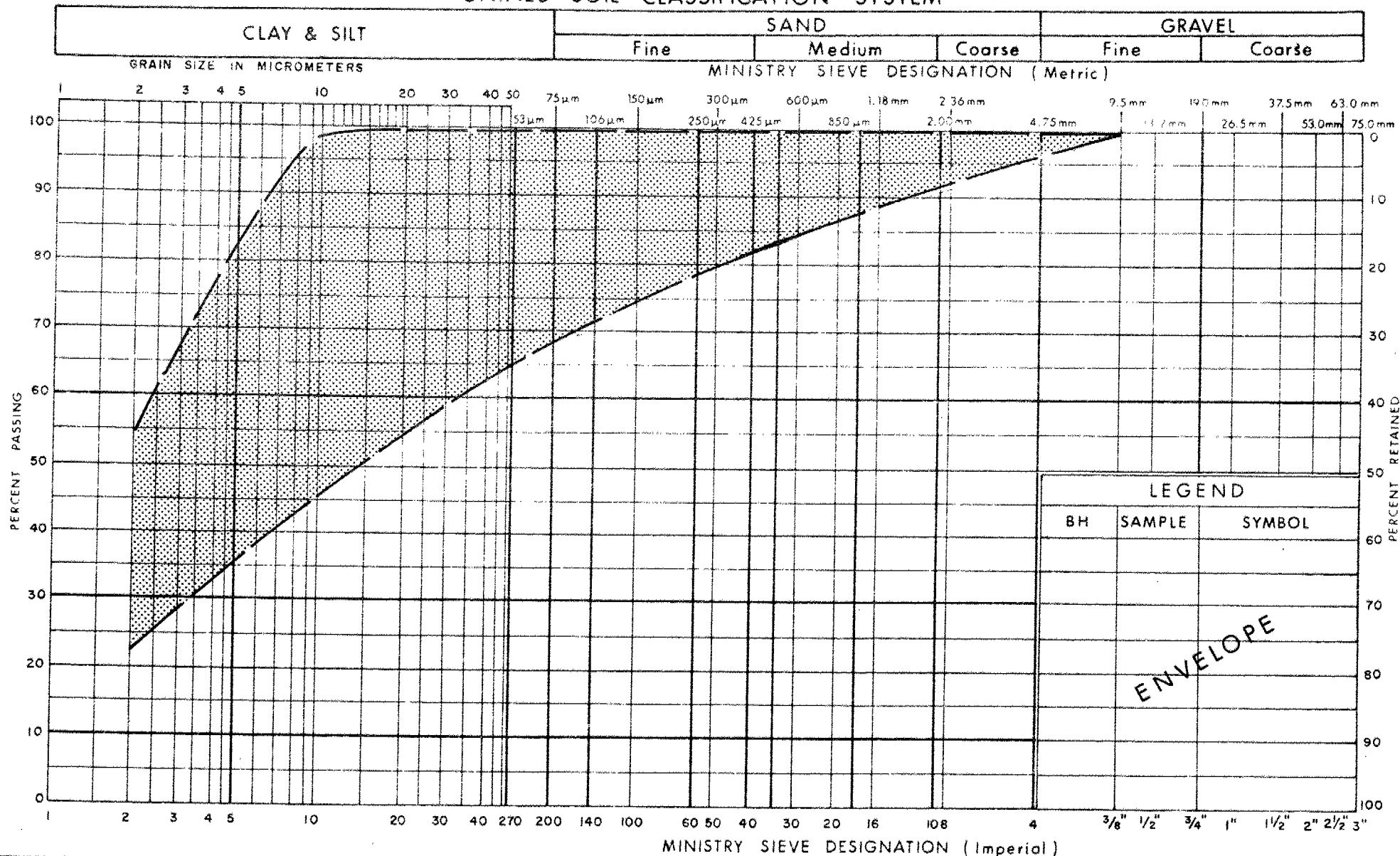
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PLASTICITY CHART HETEROGENEOUS MIXTURE OF SILTY CLAY, SAND & GRAVEL (Glacial Till)

FIG No 1

W P 37 - 69 - 02

UNIFIED SOIL CLASSIFICATION SYSTEM



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GRAIN SIZE DISTRIBUTION

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

FIG No 2

W P 37-69-02