

ENGINEERING MATERIALS OFFICE  
PAVEMENT & FOUNDATION DESIGN SECTION

WP 40-77-00

DIST 6

HWY 89

STR SITE

Hwy. 89 Extension (line 'B') over the C.N.R.

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Preliminary  
FOUNDATION INVESTIGATION REPORT  
For  
Hwy. 89 Extension (line 'B') over the C.N.R.  
W.P. 40-77-00  
District #6, Toronto

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INTRODUCTION:

This report summarizes the factual information obtained from a preliminary foundation investigation carried out on 83-09-27 at the above mentioned structure site. The fieldwork consisted of 1 sampled borehole advanced by means of hollow stem augers to a depth of 71.5 ft.

SITE DESCRIPTION

The site is located at the existing intersection of the 12th Line and the CNR tracks east of Hwy. 11, in the Township of West Gwillimbury, County of Simcoe.

Land use in the area is primarily agricultural with a small contracting company's yard to the northeast of the CNR crossing. Topography across the site is generally flat with a very gentle slope to the north.

The site is located in the physiographic region known as the "Simcoe Lowlands". This area consists primarily of sand and clay plains. The Holland Marsh lies to the south and east of this site.

SUBSURFACE CONDITIONS

General

The upper 6.5 ft of the investigated site is roadway fill comprised primarily of silty clay, some organics. Underlying the fill is a thin 4 ft. zone of firm silty clay with organics, the upper third of which is probably the parent topsoil layer. A 13.5 ft granular deposit of compact to dense sand some gravel overlies the predominant deposit of silty clay. The silty clay stratum varies from a consistency of hard to very stiff and is at least 47.5 ft thick.

The boundaries between the various soil types, insitu and laboratory test results are shown on the attached Record of Borehole Sheet. The location of the borehole is shown on Drawing No. 407700-A.

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

#### Roadway Fill; (Silty Clay, some Organics)

This fill material is part of the existing 12th Line road embankment and is 6.5 ft. thick at the borehole location.

An atterberg limits test conducted on a sample from this fill indicates the material to be a silty clay (CL zone). The results of this test are plotted on Fig. 1.

Some organic matter in the form of wood chips and root structures was found in the fill. Testing indicates that organic content ranges from 0.6 to 3.8 percent by weight, with tests completed on 2 samples from the fill.

A grain size distribution test was conducted on a sample from this layer, with results plotted on Fig. 2.

Based on Standard Penetration Test 'N' values varying from 6 to 11 blows per 1 ft. the fill appears to have undergone a moderate degree of compaction.

#### Silty Clay with Organics

Underlying the roadway fill is a 4 ft. layer of silty clay, with organics. Within the upper 1.5 ft. of this layer the old topsoil layer was found.

Organic matter content tests were conducted on both the silty clay and the topsoil. Testing indicated organic contents which ranged from 3.4 percent in the silty clay to 13.2 percent by weight in the topsoil zone.

One atterberg limits test completed on a sample from the topsoil zone indicates the material to be an organic clay (OH zone). Results are plotted on Fig. 1.

Undrained field vane shear strengths ranging from 970 to 1490 psf and Standard Penetration Test 'N' values of 5 blows per foot indicate the layer to be of a firm to stiff consistency.

#### Sand, some Gravel, trace Silt and Clay

This granular deposit was encountered at elevation 726.8 and extended down to elevation 713.3 and overlies the predominant deposit of silty clay.

Grain size distribution tests completed on samples from this layer generally indicate a well graded sand, some gravel, traces of silt and clay. The test results are plotted on Fig. 3.

The denseness of this stratum is assessed as compact to dense based on Standard Penetration Test 'N' values ranging from 14 to 38 blows per ft.

#### Silty Clay, some Sand, trace Gravel

This is the predominant soil deposit and extends from an elevation of 713.3 down to an elevation of 665.8 where drilling was ended.

Atterberg limit testing completed on 3 samples indicated the deposit to be a silty clay of low plasticity (CL zone) of plasticity chart. Test results are plotted on Fig. 4.

One grain size distribution test completed on a sample from the upper portion of this stratum indicates the silt and clay portions are predominant. This grain size distribution is plotted on Fig. 1.

Standard Penetration 'N' values varying from 114 blows per 7 in. in the upper zone to 27 blows per 1 ft. in the deepest part of the stratum indicates the consistency varies from hard to very stiff.

#### Groundwater Conditions

The groundwater level was established by taking a water level reading upon completion of the augering operation, and was found to be at an elevation of 728. A small creek on the west side of the C.N.R. tracks may affect the groundwater level by acting as a supply of water for the sand layer.

## DISCUSSION AND RECOMMENDATIONS

### General

It is planned to provide grade separation at the proposed Hwy. 89 (line B) crossing of the CNR tracks east of Hwy. 11. The proposed grade separation will entail construction of a three span structure to carry the Hwy. 89 extension over the CNR. The proposed profile grades will require earth fills in the order of 30 ft. on Hwy. 89.

The subsoil was investigated to a maximum depth of 71.5 ft. with a silty clay fill encountered in the upper 6.5 ft. Underlying the fill is a 4 ft. layer of firm to stiff silty clay with organics. A compact to dense sand stratum 13.5 ft. thick was found overlying the predominant deposit of hard to very stiff silty clay. This deposit of silty clay was found to be at least 47.5 ft. thick.

The following comments pertain to the feasibility, design and construction of the structure foundations and related earthworks, and are for preliminary design purposes only and are not intended for use in final design.

### Structure Foundations

In view of the encountered subsurface conditions it is recommended that the structure be supported on friction piles with the pile tip embedded in the hard silty clay stratum.

The following table summarizes the type of piles and related bearing capacities which may be used at this site.

<u>Pile Type</u>	<u>Approximate Pile Tip Elevation</u>	<u>Factored Axial Capacity</u>	<u>Bearing Capacity at S.L.S. Type II</u>
Size 36 Timber Butt 0, 16 inches Tip 0, 10 inches	713.0	45 tons	30 tons
Steel Tube 13 inch O @ 292 lb/ft (Concrete Filled)	705.0	65 tons	50 tons

The underside of all footing elements should be provided with a minimum of 4 ft. of earth cover for frost protection purposes.

The abutments should be backfilled with a free draining granular material and earth pressures against the abutment wall can be computed as per Subsection 6.6.1.2.2 of the O.H.B.C.D. Manual.

#### Slope Stability

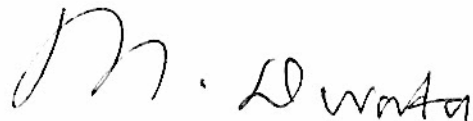
The proposed Hwy. 89 grade will require fills in the order of 30 ft. In order to insure stability of these fills the existing silty clay roadway fill and the underlying topsoil should be subexcavated. This will also ensure excessive settlement of the fill does not occur. The slopes of the proposed embankments should be constructed to a 2:1 geometry.

#### MISCELLANEOUS

The fieldwork for this investigation was carried out under the supervision of Ms. H. Inch, Student Specialist, using equipment owned and operated by Atcost Soil Investigation, Toronto. The report was written by Mr. H.J. Sturm, Project Foundation Engineer and reviewed by Mr. M. Devata, Senior Foundations Engineer.

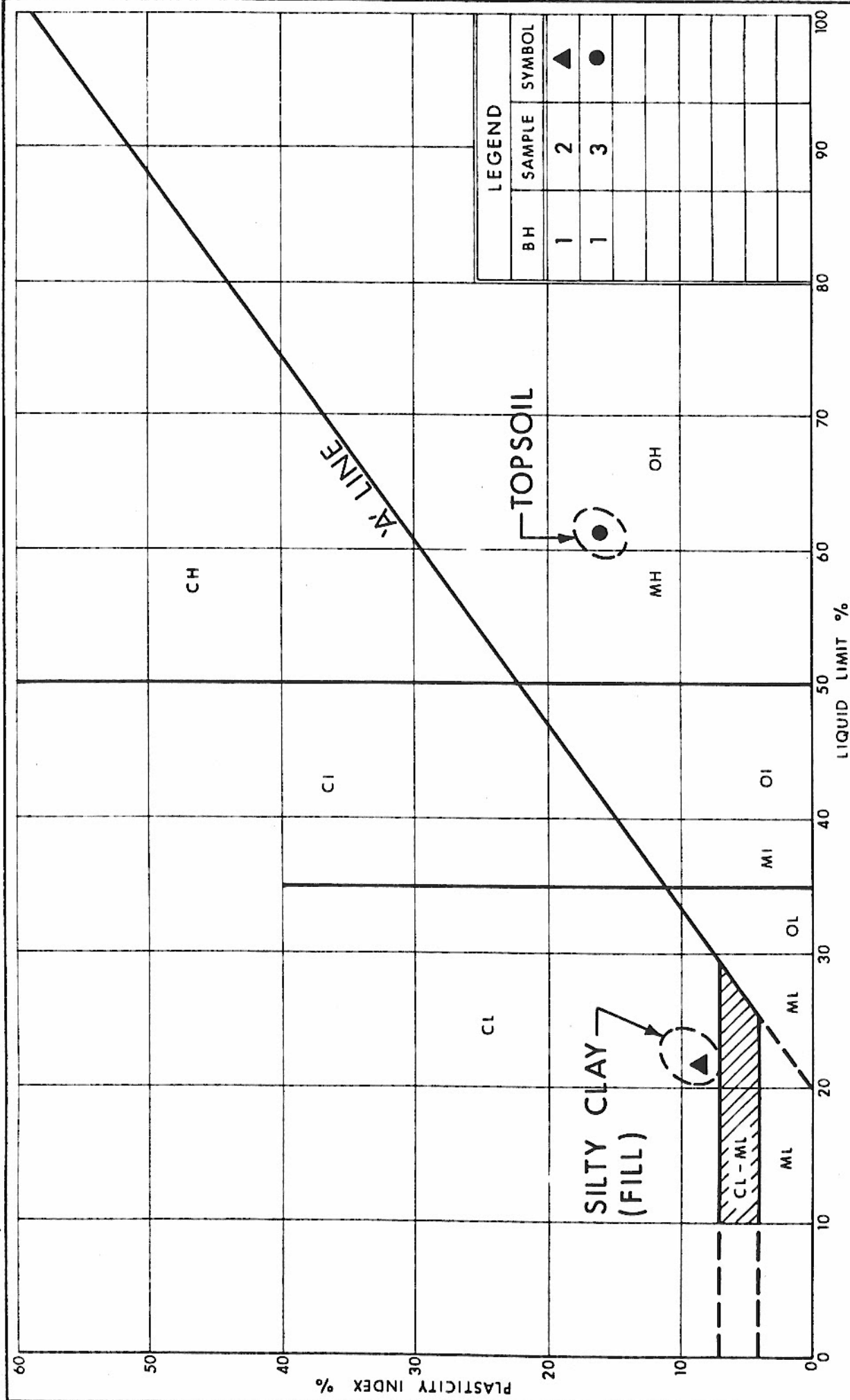


H. J. Sturm, P. Eng.  
Project Foundations Engineer



M. Devata, P. Eng.  
Senior Foundations Engineer

## APPENDIX



PLASTICITY CHART

FIG No 1

W P 40-77-00

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# UNIFIED SOIL CLASSIFICATION SYSTEM

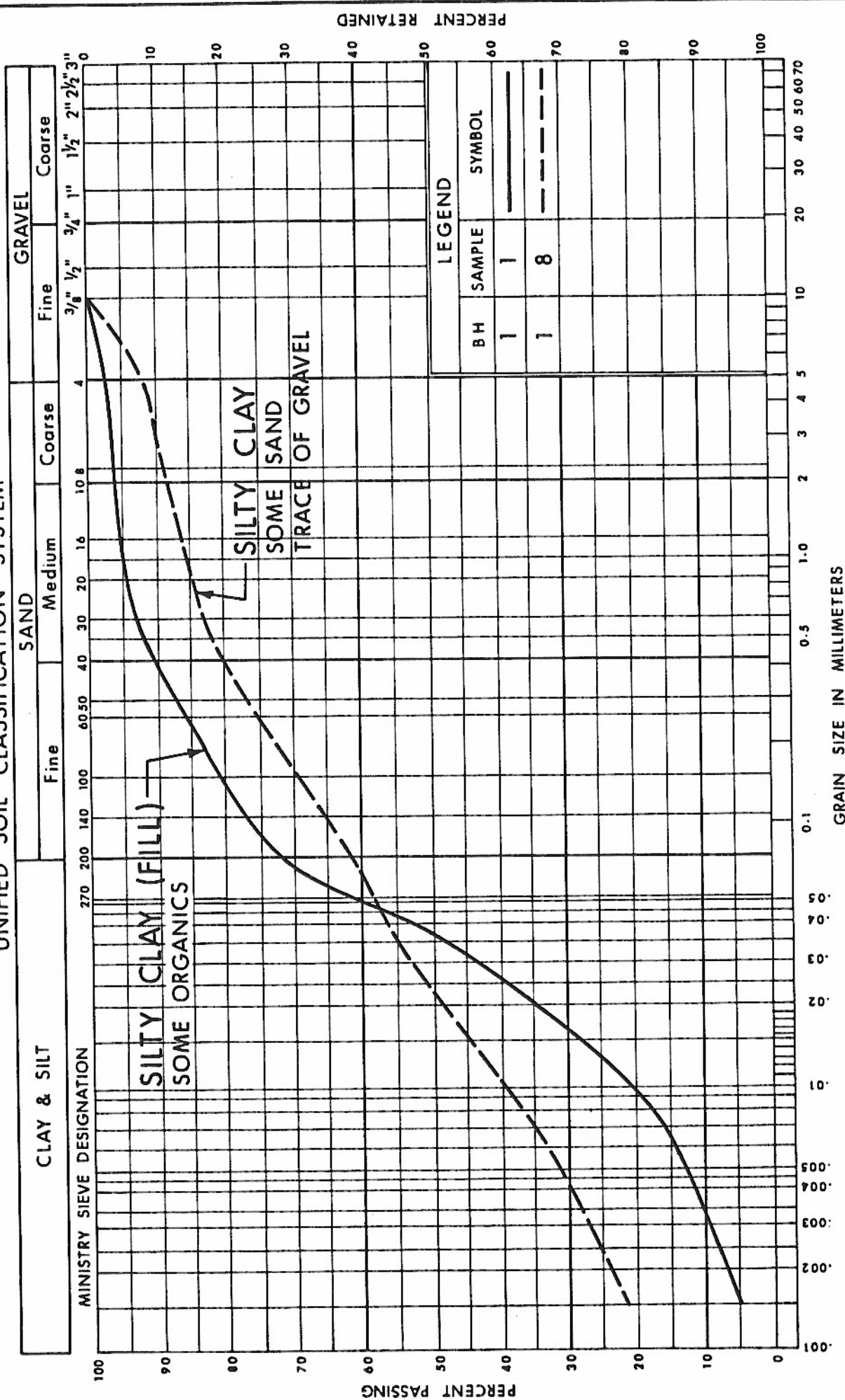
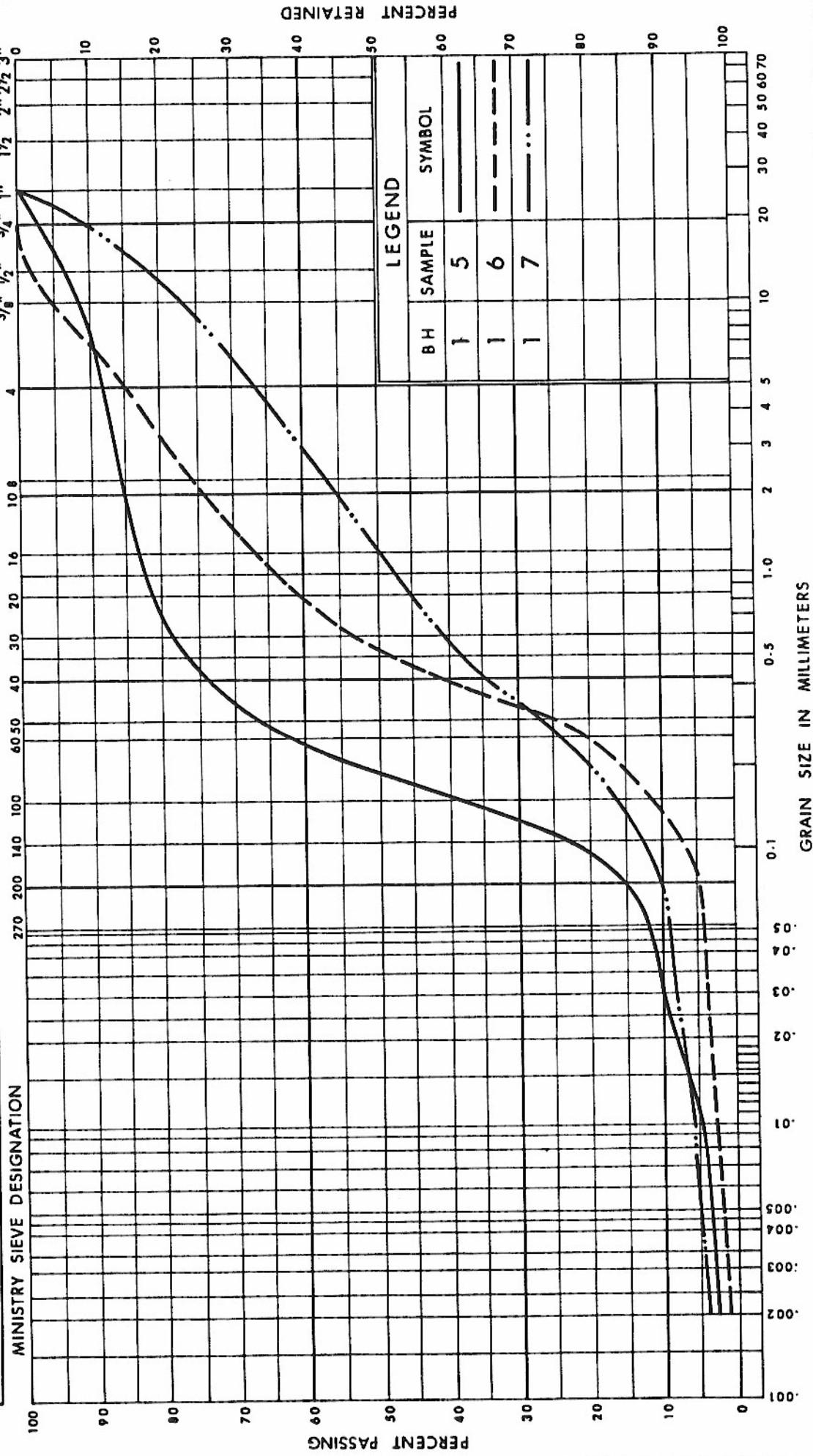


FIG No 2  
W P 40-77-00

# UNIFIED SOIL CLASSIFICATION SYSTEM

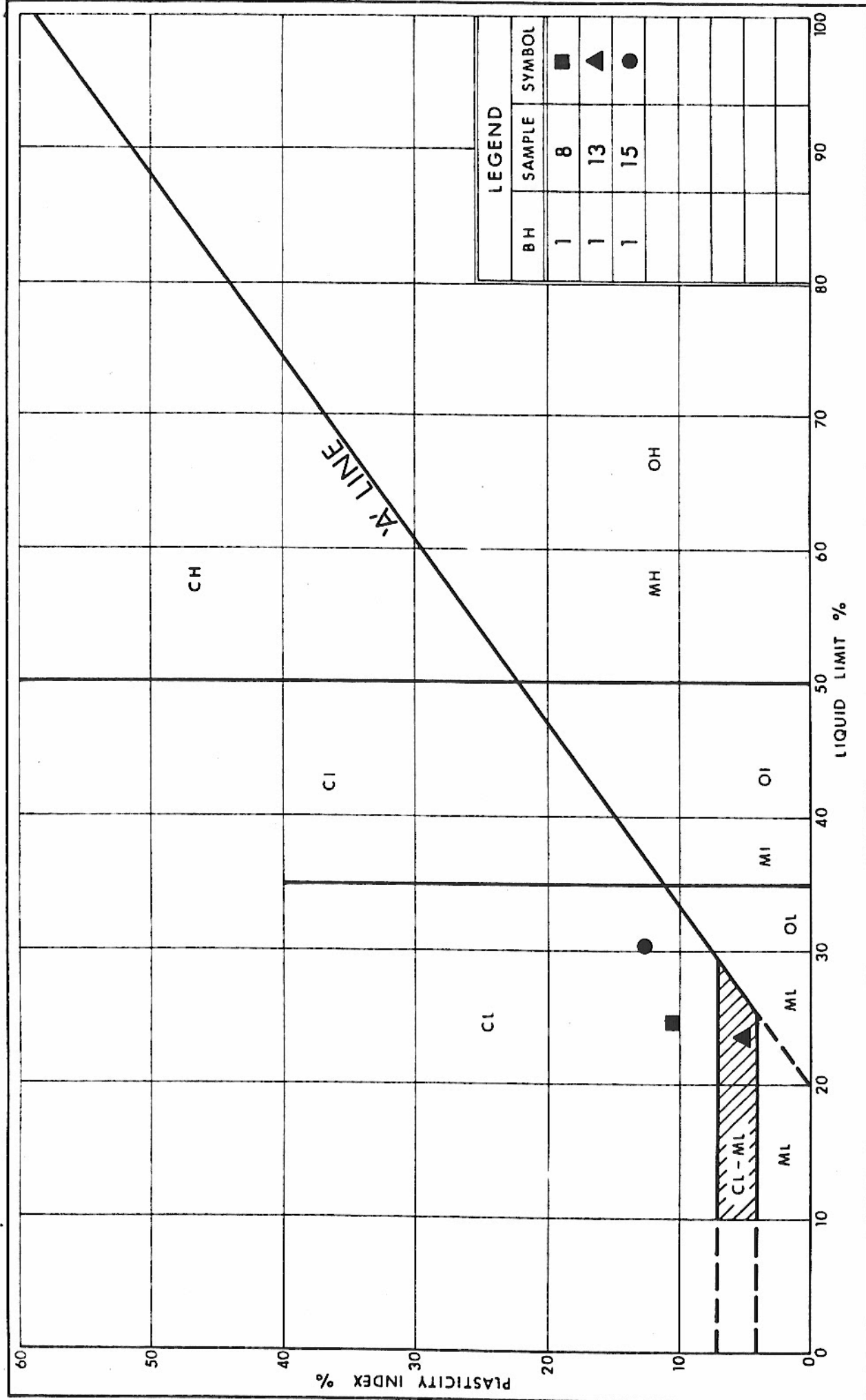
CLAY & SILT		SAND				GRAVEL			
		Fine		Medium		Coarse		Fine	
		270	200	140	100	60	50	30	20
		10.0	7.5	4.75	2.5	1.5	1.0	0.75	0.425
		3/16"	3/32"	1/16"	1/32"	1/16"	1/32"	3/64"	1/64"



**FIG No 3**

**GRAIN SIZE DISTRIBUTION**

**SAND, SOME GRAVEL TRACE OF SILT TRACE OF CLAY**



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**PLASTICITY CHART**

**SILTY CLAY, SOME SAND TRACE OF GRAVEL**

FIG No 4

W P 40-77-00

# RECORD OF BOREHOLE No 1

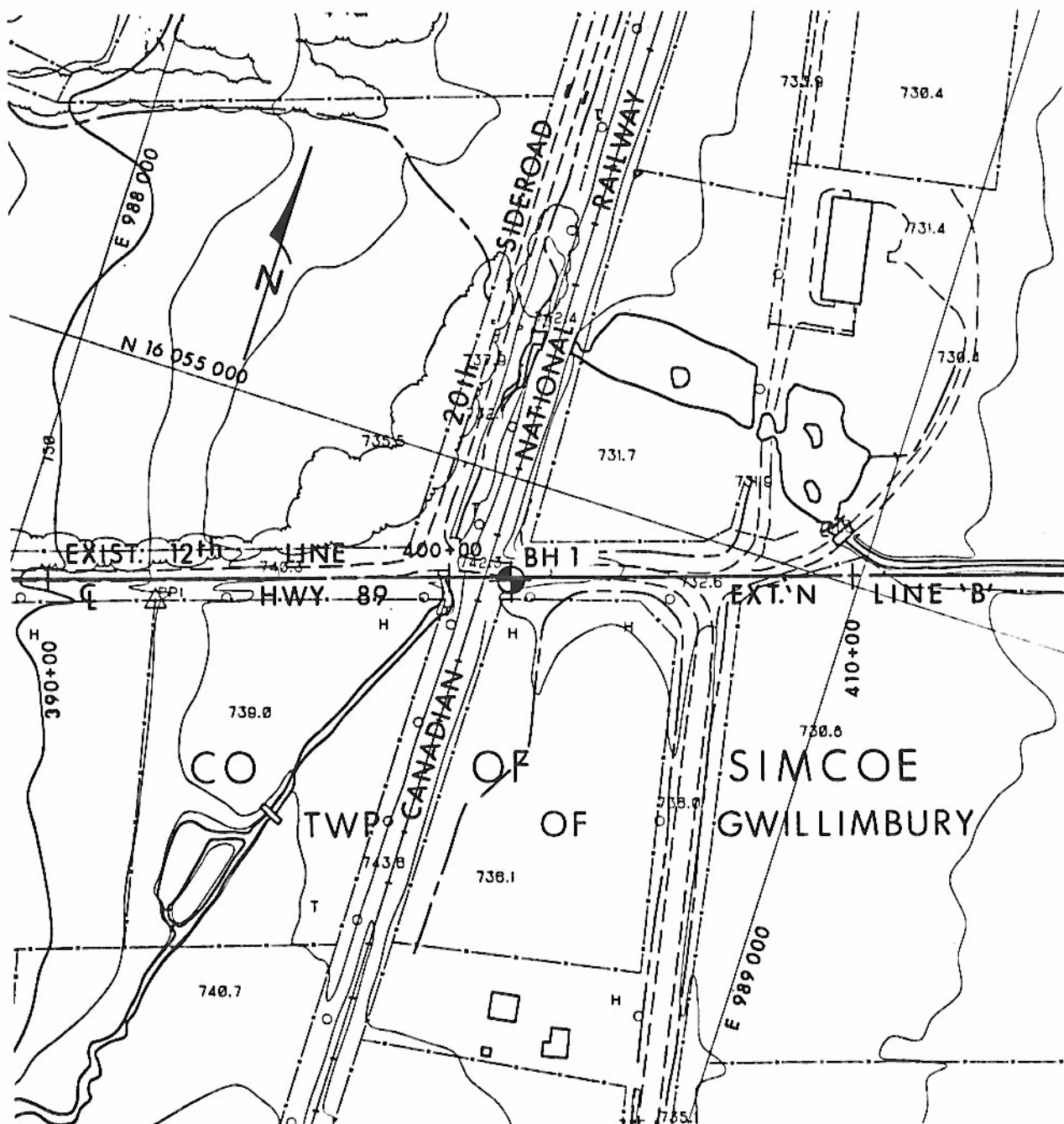
IMPERIAL

W P 40-77-00 LOCATION Co-ords. N 16 054 876; E 988 590  
DIST 6 HWY 89 Ext 'N' BOREHOLE TYPE Hollow Stem Auger and Cone Test ORIGINATED BY HI  
DATUM Geodetic DATE 1983 09 27 COMPILED BY HS  
CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH PSF							WATER CONTENT (%)			
								20 40 60 80 100										
737.3	Ground Surface																	
0.0	Fill		1	SS	11								3.8%	2 24 67 7				
730.8	Silty Clay some organics		2	SS	6													
6.5	Silty Clay Topsoil		3	SS	5								13.2%					
726.8	with organics		4	SS	5													
10.5	Sand compact		5	SS	14									12 75 11 2				
	some gravel		6	SS	18													
	trace silt													15 80 4 1				
	trace clay Dense		7	SS	38													
713.3			8	SS	48									35 54 8 3				
24.0			9	SS	100/6"													
	Silty Clay		10	SS	146/7"									8 30 38 24				
	some sand		11	SS	95													
	trace gravel		12	SS	34													
	Hard		13	SS	94													
			14	SS	44													
			15	SS	35													
			16	SS	27													
	Very Stiff		17	SS	28													
665.8	End of Borehole																	
71.5	*Note: Water Level after completion of augering operations.																	
	**Org.M. indicates percentage of organic matter by weight.																	

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

OFFICE REPORT ON SOIL EXPLORATION



PLAN SCALE 1" = 200'

GEOCREs No 31D-306

PRELIMINARY INVESTIGATION  
HWY 89 EXTENSION LINE 'B' OVER  
CANADIAN NATIONAL RAILWAY

DWG No 407700-A

DIST 6  
W P 40-77-00

# EXPLANATION OF TERMS USED IN REPORT

**'N' VALUE:** AN INDICATOR OF SUBSOIL QUALITY. IT IS OBTAINED FROM THE STANDARD PENETRATION TEST (CSA STD. A119.1). SPT 'N' VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 2 INCH O.D. SPLIT-BARREL SAMPLER TO PENETRATE 12 INCHES INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WEIGHING 140 POUNDS, FALLING FREELY A DISTANCE OF 30 INCHES. FOR PENETRATIONS OF LESS THAN 12 INCHES 'N' VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. 'N' VALUES CORRECTED FOR OVERBURDEN PRESSURE ARE DENOTED THUS  $N_c$ .

**DYNAMIC CONE PENETRATION TEST (CSA STD. A119.3):** CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (2" O.D. 60 CONE ANGLE) DRIVEN BY 350 FT-LB IMPACTS ON "A" SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 12 INCH ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

**SOIL QUALITY:** SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSITY.

**CONSISTENCY:** COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH AS FOLLOWS:

$S_u$ (PSF)	0 - 250	250 - 500	500 - 1000	1000 - 2000	2000 - 4000	> 4000
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

**DENSENESS:** COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF SPT 'N' VALUES AS FOLLOWS:

'N' (BLOW/FT)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

**ROCK QUALITY:** 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 DRILLED IN THAT CORING RUN.

**MODIFIED RECOVERY:** SUM OF THOSE NATURALLY FRACTURED CORE PIECES, 4" 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	2"	2" - 12"	1' - 3'	3' - 10'	> 10'
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

## ABBREVIATIONS & SYMBOLS




### LABORATORY TESTING

TRIAxIAL TESTS ARE DESCRIBED IN TERMS OF WHETHER THEY ARE CONSOLIDATED (C) OR NOT (U) ISOTROPICALLY (I) OR NOT (A) AND SHEARED DRAINED (D) OR UNDRAINED (U) WITH PORE PRESSURE MEASUREMENTS (BAR OVER SYMBOLS) EG.  $\bar{C}IU$  = CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL WITH PORE PRESSURE MEASUREMENT UNLESS OTHERWISE SPECIFIED IN REPORT ALL TESTS ARE IN COMPRESSION

### FIELD SAMPLING

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

### EARTH PRESSURE TERMS

$\mu$  COEFFICIENT OF FRICTION  
 $\delta$  ANGLE OF WALL FRICTION  
 $k_o$  COEFFICIENT OF EARTH PRESSURE AT REST  
 $k_A$  COEFFICIENT OF ACTIVE EARTH PRESSURE  
 $k_P$  COEFFICIENT OF PASSIVE EARTH PRESSURE  
 $i$  ANGLE OF INCLINATION OF SURCHARGE   
 $w$  SLOPE ANGLE-BACKFACE OF WALL   
 $\beta$  ANGLE OF SLOPE   
 $N_\gamma, N_q, N_c$  BEARING CAPACITY FACTORS  
 $D_f$  DEPTH OF FOOTING  
 $B, L$  FOOTING DIMENSIONS

### INDEX PROPERTIES

$\gamma$  UNIT WEIGHT OF SOIL (BULK DENSITY)  
 $\gamma_w$  UNIT WEIGHT OF WATER  
 $\gamma_d$  UNIT DRY WEIGHT OF SOIL (DRY DENSITY)  
 $\gamma'$  UNIT WEIGHT OF SUBMERGED SOIL  
 $G_s$  SPECIFIC GRAVITY OF SOLIDS  
 $e$  VOIDS RATIO  
 $e_o$  INITIAL VOIDS RATIO  
 $e_{max}$   $e$  IN LOOSEST STATE  
 $e_{min}$   $e$  IN DENSEST STATE  
 $D_r$  RELATIVE DENSITY =  $\frac{e_{max} - e}{e_{max} - e_{min}}$   
 $n$  POROSITY  
 $w$  WATER CONTENT  
 $w_L$  LIQUID LIMIT  
 $w_p$  PLASTIC LIMIT  
 $w_s$  SHRINKAGE LIMIT  
 $I_p$  PLASTICITY INDEX =  $w_L - w_p$   
 $I_L$  LIQUIDITY INDEX =  $\frac{w - w_p}{w_L - w_p}$   
 $I_c$  CONSISTENCY INDEX =  $\frac{w_L - w}{w_L - w_p}$   
 $A_c$  ACTIVITY =  $\frac{I_p \text{ of soil}}{I_p \text{ of } \mu m \text{ Soil Fraction}}$   
 $O_m$  ORGANIC MATTER CONTENT  
 $S_r$  DEGREE OF SATURATION  
 $S$  SENSITIVITY =  $\frac{S_u(\text{undisturbed})}{S_u(\text{remoulded})}$

### STRENGTH PARAMETERS

$\phi$  ANGLE OF SHEARING RESISTANCE  
 $\tau_f$  PEAK SHEAR STRENGTH  
 $\tau_R$  RESIDUAL SHEAR STRENGTH  
 $c$  COHESION INTERCEPT  
 $\sigma_1, \sigma_2, \sigma_3$  NORMAL PRINCIPAL STRESSES  
 $u$  PORE WATER PRESSURE  
 $u_e$  EXCESS  $u$   
 $r_u$  PORE PRESSURE RATIO  
 $q_u$  UNCONFINED COMPRESSIVE STRENGTH  
 $s_u$  UNDRAINED SHEAR STRENGTH  
 $\epsilon$  LINEAR STRAIN  
 $\gamma$  SHEAR STRAIN  
 $\nu$  POISSON'S RATIO  
 $E$  MODULUS OF ELASTICITY  
 $G$  MODULUS OF SHEAR DEFORMATION  
 $k_s$  MODULUS OF SUBGRADE REACTION  
 $m, n$  STABILITY COEFFICIENTS  
 $A, B$  PORE PRESSURE COEFFICIENTS

### HYDRAULIC TERMS

$h$  HYDRAULIC HEAD OR POTENTIAL  
 $q$  RATE OF DISCHARGE  
 $v$  VELOCITY OF FLOW  
 $i$  HYDRAULIC GRADIENT  
 $j$  SEEPAGE FORCE PER UNIT VOLUME  
 $\eta$  COEFFICIENT OF VISCOSITY  
 $k$  COEFFICIENT OF HYDRAULIC CONDUCTIVITY  
 $k_h$   $k$  IN HORIZONTAL DIRECTION  
 $k_v$   $k$  IN VERTICAL DIRECTION  
 $m_v$  COEFFICIENT OF VOLUME CHANGE  
 $c_v$  COEFFICIENT OF CONSOLIDATION  
 $C_c$  COMPRESSION INDEX  
 $C_r$  RECOMPRESSION INDEX  
 $d$  DRAINAGE PATH DISTANCE  
 $T_v$  TIME FACTOR  
 $U$  DEGREE OF CONSOLIDATION  
 $O_r$  OVERCONSOLIDATION RATIO (OCR)

**NOTE:** EFFECTIVE STRESS PARAMETERS ARE DENOTED BY USE OF APOSTROPHE ABOVE THE SYMBOL, THUS:  
 $\phi'$  = EFFECTIVE ANGLE OF SHEARING RESISTANCE;  
 $\sigma'$  = EFFECTIVE NORMAL STRESS