

DOCUMENT MICROFILMING IDENTIFICATION

G.I.-30 SEPT. 1976

GEOCRES No. 4076-9

DIST. 1 REGION

W.P. No. 260-66-03

CONT. No. 81-05
(see also 89-41)

W. O. No.

STR. SITE No. 6-275

HWY. No. ~~18~~ ECR

LOCATION Malden Rd. Overpass

No. of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

ENGINEERING MATERIALS OFFICE
SOIL MECHANICS SECTION

WP 260-66-03

DIST 1

HWY ECR

STR SITE 6-275

Malden Road Overpass
1.2 Miles East of Hwy. 18 - Windsor

DISTRIBUTION

A.P. Watt (2)
J.R. Roy
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SAMPLE DISPOSITION NOTICE		
TYPE	DISCARD AFTER	RECOMM. BY
JARS	77-11-07	1248
TUBES	77-11-07	1248
ROCK CORES	77-11-07	1248

FOUNDATION INVESTIGATION REPORT

For

Malden Road Overpass
1.2 Miles East of Hwy. 18 - Windsor
Hwy. ECR, District 1, Chatham
W.P. 260-66-03, Site 6-275

INTRODUCTION

This report contains the results of our foundation investigation carried out for the proposed overpass structure. The fieldwork was carried out during the period of February 22-28, 1968, utilizing a continuous flight auger machine mounted on a muskeg vehicle and equipped with solid augers. The report also contains recommendations relating to the design and construction of the proposed structures and approaches.

SITE DESCRIPTION

The site is located 1.2 miles east of Hwy. 18 along the proposed E.C. Row Expressway alignment within the City of Windsor. The surrounding terrain is flat residential area.

Physiographically the site is located in the region referred to as the St. Clair Clay Plain.

SUBSURFACE CONDITIONS

General

Generally uniform subsoil conditions were found to prevail over the site area. The subsoil consists of a shallow layer of silty sand, underlain by a deep deposit of silty clay to clayey silt, containing some sand and traces of gravel, followed by a sandy silt stratum which is in turn underlain by sound limestone bedrock. The boundaries of the different deposits are shown on the Record of Borehole Sheets attached to the Appendix. The estimated stratigraphical profiles of Drawing 2606603-A is based upon this information. Soil types encountered from ground level downward are described in some detail below.

Silty Sand

This deposit was intersected in all borings from immediately below the ground surface to a depth of about 4 feet. The material consists of silty sand. The

upper portion was found to be frozen at the time of the field investigation. The relative density is estimated to be compact.

Silty Clay to Clayey Silt

The silty sand is underlain by an extensive cohesive type stratum at each boring location. The lower boundary of the deposit was encountered between elevation 496 and elevation 500. It was penetrated fully only in B.H. 1 and 3. The material in the deposit consists of silty clay to clayey silt, some sand and traces of gravel. A plot of plasticity index versus liquid limit (Fig. 1) shows the points to fall within the CL and CI zones indicating a low to medium plasticity. Physical properties of the overall deposit as determined from field and laboratory tests are as follows:

Natural Moisture Content (%)	17- 29
Liquid Limit (%)	23- 41
Plastic Limit (%)	14- 21
Bulk Density (PCF)	115- 134
Unconfined Shear Strength (PSF)	600-4690
Field Vane Test (PSF)	1000-2000+
Sensitivity	1.6- 3.2

The results of mechanical analyses are shown in an envelope form on Figure 2.

The undrained shear strength of the deposit in general decreases with depth. For design purposes the following undrained shear strength values are suggested:

Above Elev. 580	- 2000 PSF
Elev. 565-Elev. 580	- 1500 PSF
Elev. 565-Elev. 500	- 1000 PSF

The consistency of the overall deposit ranges from firm to very stiff.

Sandy Silt

An approximate 5-10 foot thick sandy silt, some gravel zone was found to underlie the cohesive deposit. The relative density is estimated to be very dense.

Limestone Bedrock

The bedrock was proven at one borehole location (B.H. #1) by obtaining AXT size core. The bedrock was found to be sound limestone, the surface being at elevation 490±.

Groundwater Conditions

Groundwater level observations have been carried out during the course of fieldwork by recording the water levels in the open boreholes. The following groundwater levels were observed:

B.H. #1 Elev. 591

B.H. #2 Elev. 591

B.H. #3 Elev. 590

B.H. #4 Not observed

These figures indicate that the groundwater level is located some 2-3 feet below the existing ground level.

DISCUSSION AND RECOMMENDATIONS

General

It is proposed to build a three span (35'-66'-35') twin overpass structure at this location. The profile grade of E.C. Row Expressway is set at elevation 614, some 21 feet above Malden Road surface. The existing ground surface adjacent to the proposed structure site is at about elevation 593±.

Structure Foundations

It is recommended that the entire structure (abutments and piers) be founded on end bearing piles driven to bedrock. The bedrock surface is located some 95 feet below ground level. These piles could be either steel 'H' piles or concrete filled steel tube piles. Design loads could be as high as 130 tons/pile for either 12 3/4" x 1/4" steel tubes or 12BP074 steel 'H' sections. The tips of steel 'H' piles should be reinforced. If tube piling is selected the driving energy should not exceed 30,000 ft. lbs. per blow below elevation 500 to avoid damage to the pile tips when contact with the bedrock is made.

The pile caps should be protected against frost action by at least 4 feet of earth cover.

No major dewatering problems are anticipated.

Approach Embankments

The shear strength of the subsoil is such that it will be able to support the 21 foot high approach embankments constructed with 2:1 slopes. The fill should consist of well compacted acceptable material. Care should be taken to ensure that no bouldery fill is placed within the approaches through which piles have to be driven and it is recommended that this portion of the fill contain no larger grain sizes than 2 inches.

It is estimated that a maximum settlement of 4-5 inches will take place over a long period of time under the 21 foot high fill at the abutment locations. It is also estimated that 50% of the predicted settlement will be completed in about 6 months' time. To minimize the effect of the settlement on the performance of the structure it is recommended that the approaches be built in advance of the structure for as long a period as possible.

MISCELLANEOUS

The field investigation was carried out under the supervision of Mr. A.M. Seppala, Project Engineer. The equipment used was owned and operated by Canadian Longyear Ltd. This report was written by Mr. P. Payer.

P. Payer
P. Payer, P. Eng.
Senior Engineer



K. G. Selby
K.G. Selby, P. Eng.
Supervising Engineer

KGS/PP/gs
November, 1977

APPENDIX



Ministry of
Transportation and
Communications

HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 1 (Formerly B.H.5 W.O. 68-F-15-1)

W P 260-66-03 LOCATION Co-ords N 15,358,550; E 848,663 ORIGINATED BY AMS
DIST 1 HWY E.C. Row Expwy BOREHOLE TYPE Cont. Flight Auger (Bombardier) AXT Rock Core & Cone Test COMPILED BY AMS
DATUM Geodetic DATE Feb., 21 & 22, 1968 CHECKED BY RS

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 PCF	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
592.8	Ground Level																
0.0	Silty Sand						590	Frozen Zone									
588.8	Compact																
4.0			1	SS	5												
			2	SS	20												
			3	SS	18												
	Silty Clay		4	SS	9												
	To		5	TW	PH												
	Clayey Silt		6	TW	PH												
	Some Sand		7	TW	PH												
	Trace of Gravel		8	TW	PH												
	Firm to Very Stiff		9	TW	PH												
			10	TW	PH												
			11	TW	PM												
			12	TW	PM												
			13	TW	PM												
			14	TW	PM												
499.8																	
93.0	Sandy Silt																
	Some Gravel																
490.0	Very Dense																
102.8	Limestone Bedrock		15	AXT RC	REC 100%		490										
484.6	Sound																
108.2	End of Borehole																

+3, x5: Numbers refer to Sensitivity
20
15 \diamond 5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION



Ministry of
Transportation and
Communications
Ontario

HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 2 (Formerly B.H.6 W.O. 68-F-15-1)

W P 260-66-03 LOCATION Co-ords N 15,358,662; E 848,637 ORIGINATED BY AMS
DIST 1 HWY E.C.Row Expwy BOREHOLE TYPE Cont. Flight Auger (Bombardier) & Cone Test COMPILED BY AMS
DATUM Geodetic DATE Feb., 23, 1968 CHECKED BY RS

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 PCF	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
593.0	Ground Level																
0.0	Silty Sand																
589.0	Compact																
4.0	Silty Clay To Clayey Silt Some Sand Trace of Gravel Firm to Very Stiff		1	SS	6		590									124	1 11 38 50
			2	TW	PH		580										
			3	TW	PH												
			4	TW	PM												
			5	TW	PM		570									127	
			6	TW	PM												
			7	TW	PM		560										
			8	TW	PM												
551.5																	3 17 45 35
41.5	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 3 (Formerly B.H.7.W.O. 68-F-15-1)

W P 260-66-03 LOCATION Co-ords N 15,358,707; E 848,504 ORIGINATED BY AMS
DIST 1 HWY E.C. Row Expwy BOREHOLE TYPE Cont. Flight Auger (Bombardier) & Cone Test COMPILED BY AMS
DATUM Geodetic DATE Feb. 26 & 27, 1968 CHECKED BY RS

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 PCF	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	500 1000 1500 2000 2500					
592.3	Ground Level													
0.0	Silty Sand													
588.3	Compact													
4.0														
	Silty Clay		1	SS	7									
	To		2	TW	PH								125	0 9 31 60
	Clayey Silt		3	SS	11									
	Some Sand		4	TW	PM								124	
	Trace of Gravel		5	TW	PM									
	Firm To Stiff		6	TW	PM								127	
			7	TW	PM									
			8	TW	PM								126	3 15 40 42
			9	TW	PM									
			10	TW	PM								115	1 19 55 25
			11	TW	PM									
			12	TW	PM								132	3 20 38 39
			13	TW	PM									
			14	TW	PM									
496.3														
96.0	Sandy Silt, Some Gravel													
491.0	Very Dense													
101.3	End of Borehole (Refusal)													

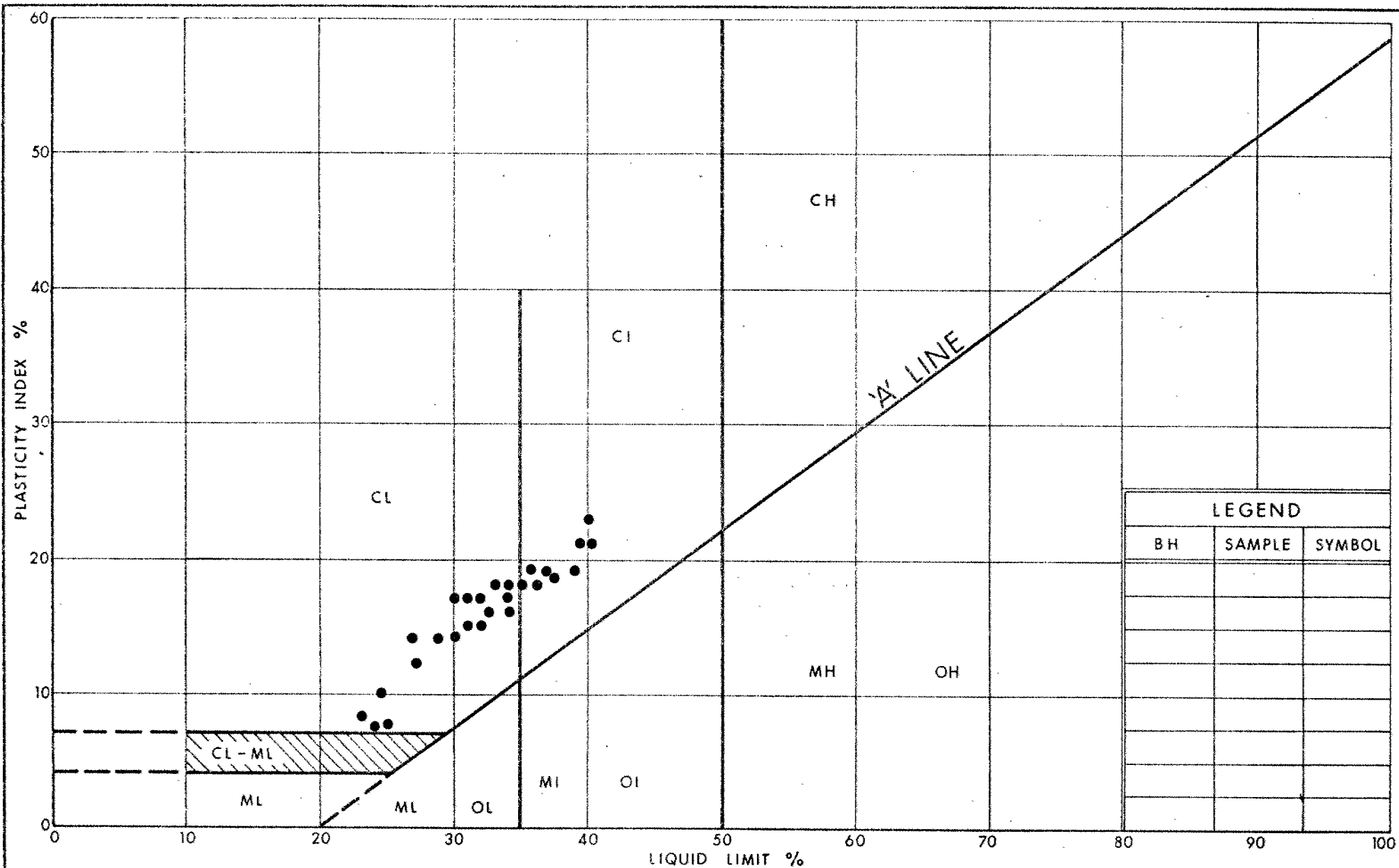
OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 4 (Formerly B.H.8 W.O. 68-F-15-1)

W P 260-66-03 LOCATION Co-ords N 15,358,594: E 848,573 ORIGINATED BY AMS
DIST 1 HWY E.C.Row Expwy BOREHOLE TYPE Cont. Flight Auger (Bombardier) & Cone Test COMPILED BY AMS
DATUM Geodetic DATE Feb. 27, 1968 CHECKED BY RS

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					
593.6	Ground Level																
0.0	Silty Sand																
589.6	Compact																
4.0																	
	Silty Clay To Clayey Silt Some Sand Trace of Gravel Firm To Stiff		1	SS	4												
			2	TW	PH											129	
			3	TW	PH												
			4	TW	PH											123	0 13 41 46
			5	TW	PH												
			6	TW	PH											124	
			7	TW	PH												
			8	TW	PH											127.5	1 16 44 39
550.6																	
43.0	End of Borehole																
	Note Water Level Not Established																

OFFICE REPORT ON SOIL EXPLORATION

Ministry of
Transportation and
Communications

PLASTICITY CHART
SILTY CLAY TO CLAYEY SILT

FIG No 1

W P 260 - 66 - 03



GRAIN SIZE DISTRIBUTION
SILTY CLAY TO CLAYEY SILT

W P 260 - 66 - 03

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. CUU = CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL WITH PORE PRESSURE MEASUREMENT UNLESS OTHERWISE SPECIFIED IN REPORT ALL TESTS ARE IN COMPRESSION

FIELD SAMPLING

S S SPLIT SPOON
W S WASH SAMPLE
S T SLOTTED TUBE SAMPLE
B S BLOCK SAMPLE
C S CHUNK SAMPLE
T W THINWALL OPEN
T P THINWALL PISTON
O S OSTERBERG SAMPLE
F S FOIL SAMPLE
R C ROCK CORE
P H T.W. ADVANCED HYDRAULICALLY
P M T.W. ADVANCED MANUALLY

EARTH PRESSURE TERMS

μ COEFFICIENT OF FRICTION
 δ 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
 β ANGLE OF SLOPE
 N_q, N_c, N_{γ} BEARING CAPACITY FACTORS
 D_f DEPTH OF FOOTING
 B, L FOOTING DIMENSIONS

INDEX PROPERTIES

γ UNIT WEIGHT OF SOIL (BULK DENSITY)
 γ_w UNIT WEIGHT OF WATER
 γ_d UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
 γ' 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 = $w_L - w_P$
 L_L LIQUIDITY INDEX = $\frac{w - w_P}{p}$
 I_C CONSISTENCY INDEX = $\frac{w_L - w}{I_P}$
 A_C ACTIVITY = $\frac{I_P \text{ of soil}}{I_P \text{ of } 2\mu m \text{ soil fraction}}$
 O_m ORGANIC MATTER CONTENT
 S_r DEGREE OF SATURATION
 S SENSITIVITY = $\frac{S_u \text{ (undisturbed)}}{S_u \text{ (remoulded)}}$

STRENGTH PARAMETERS

ϕ ANGLE OF SHEARING RESISTANCE
 τ_f PEAK SHEAR STRENGTH
 τ_R RESIDUAL SHEAR STRENGTH
 c COHESION INTERCEPT
 $\sigma_1, \sigma_2, \sigma_3$ NORMAL PRINCIPAL STRESSES
 u PORE WATER PRESSURE
 u_e EXCESS u
 u_d PORE PRESSURE RATIO
 q_u UNCONFINED COMPRESSIVE STRENGTH
 s_u UNDRAINED SHEAR STRENGTH
 ϵ LINEAR STRAIN
 γ SHEAR STRAIN
 ν POISSON'S RATIO
 E MODULUS OF ELASTICITY
 G MODULUS OF SHEAR DEFORMATION
 k_a 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
 η 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_c OVERCONSOLIDATION RATIO (OCR)

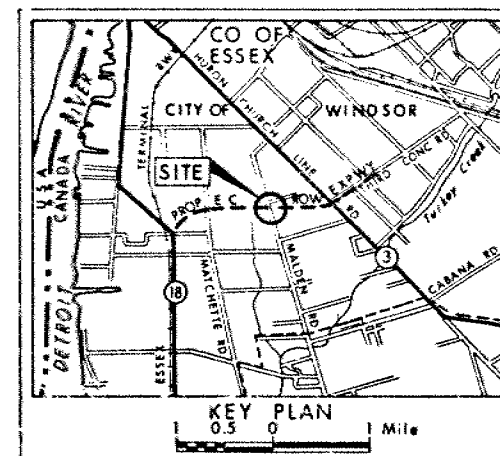
NOTE: EFFECTIVE STRESS PARAMETERS ARE DENOTED BY USE OF APOSTROPHE ABOVE THE SYMBOL, THUS: σ' = EFFECTIVE ANGLE OF SHEARING RESISTANCE; σ' = EFFECTIVE NORMAL STRESS

CONT No
WP No 260-66-03



MALDEN RD O'PASS
(1.2 Miles E of Hwy 18)
BORE HOLE LOCATIONS & SOIL STRATA

SHEET



LEGEND

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊙ Bore Hole & Cone
- 'N' Blows/ft (Std Pen Test 350 ft lbs energy)
- CONE Blows/ft (60° Cone, 350 ft lbs energy)
- WL at time of investigation FEB 1968
- WL NOT Established for Bore Hole 4

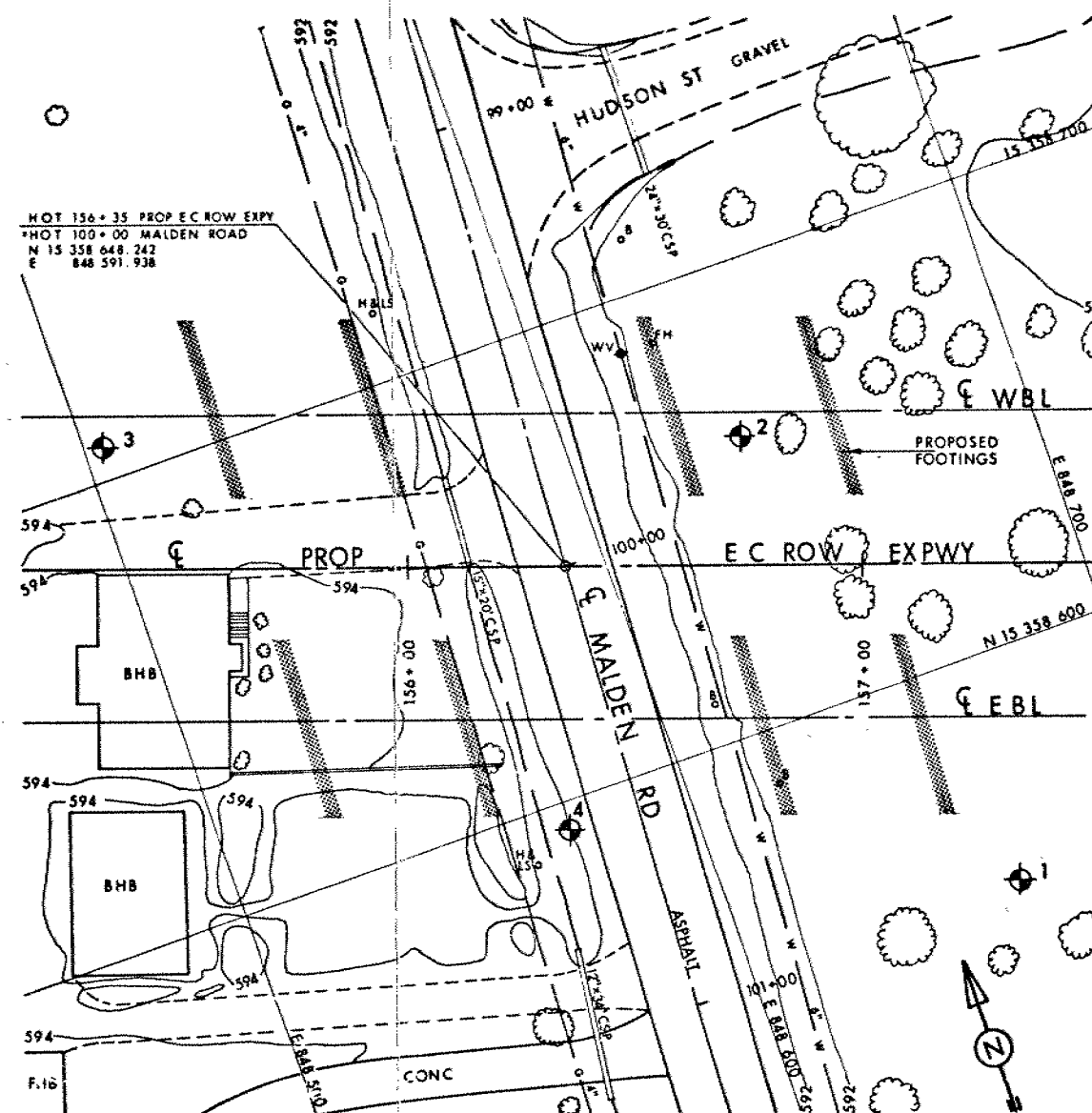
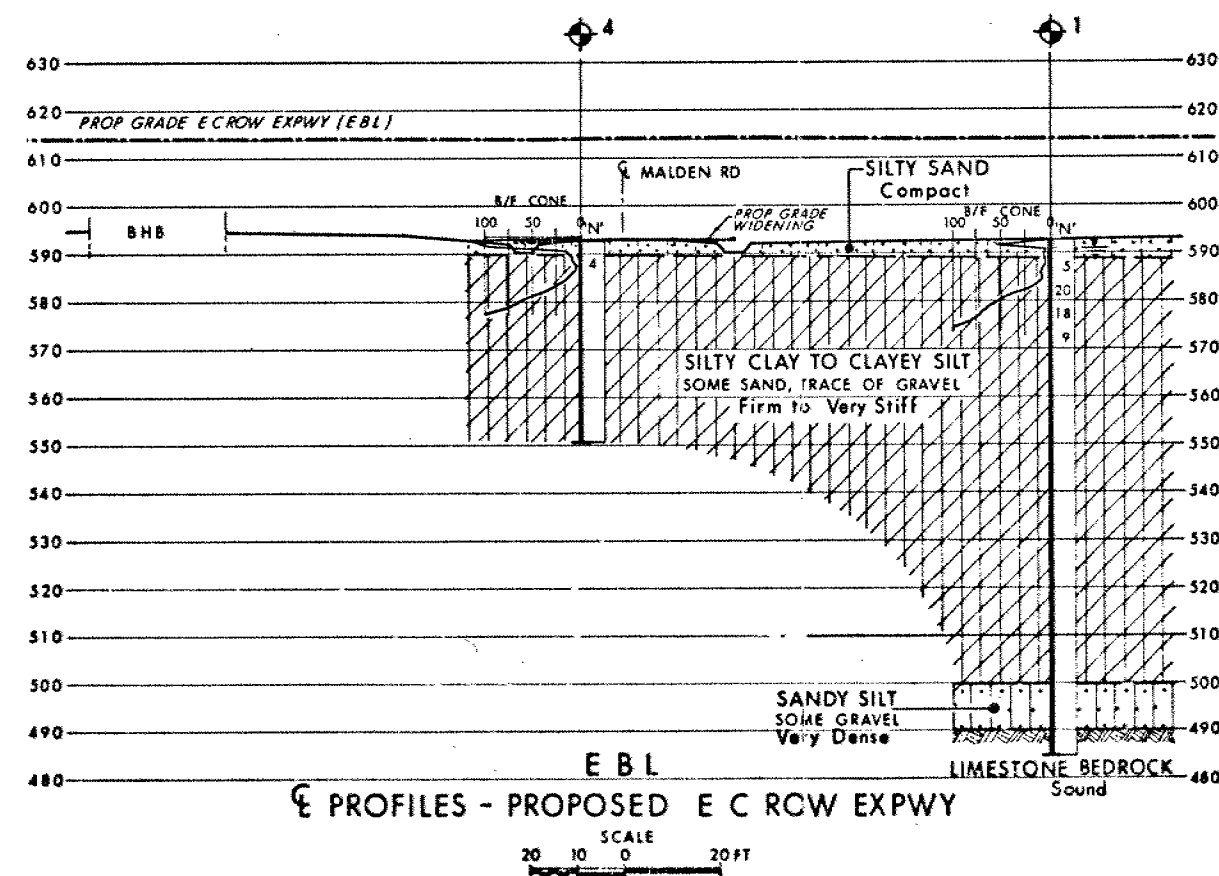
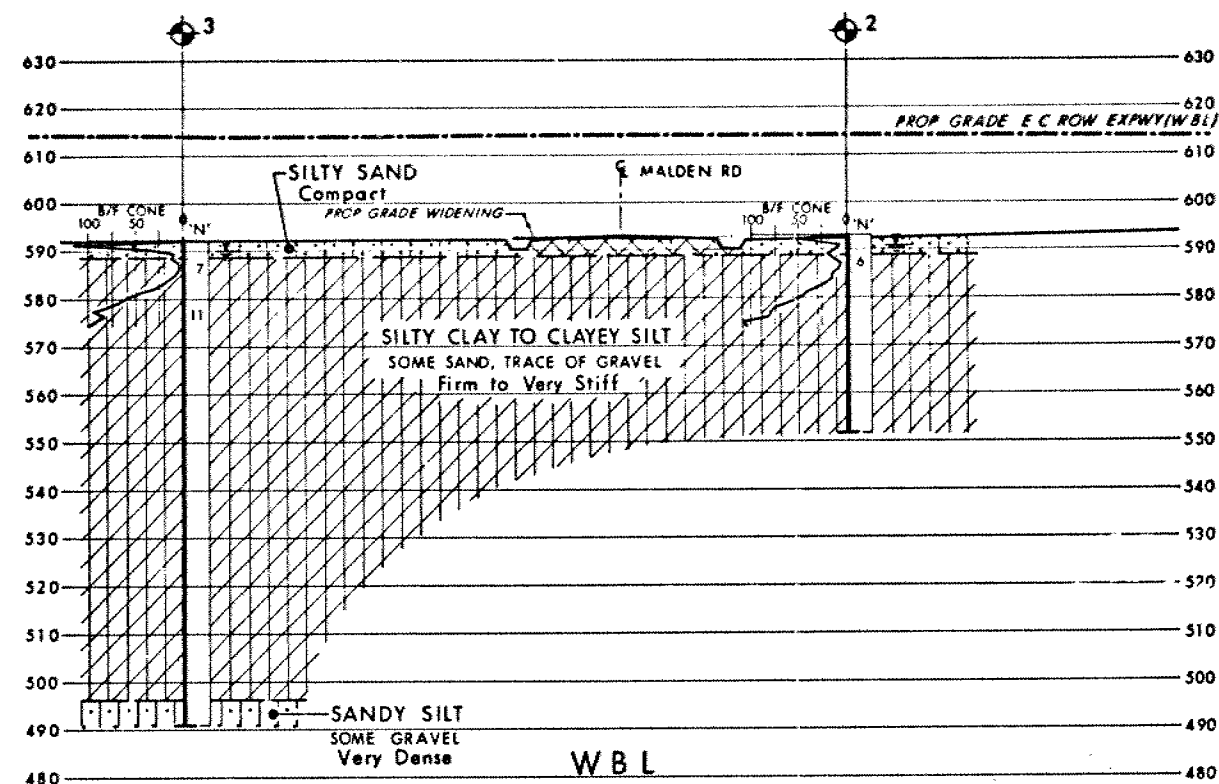
No	ELEVATION	CO-ORDINATES		FORMERLY WO: 68-F-15-1
		NORTH	EAST	
1	592.8	15 358 550	848 663	BH 5
2	593.0	15 358 662	848 637	BH 6
3	592.3	15 358 707	848 504	BH 7
4	593.6	15 358 594	848 573	BH 8

-NOTE-

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

HWY No PROPOSED E.C. ROW EXPWY DIST 1
SUBMIT P.P. CHECKED DATE Oct 20, 1977, SITE 6-275
DRAWN R.S. CHECKED DATE 11/2/77, SITE 2606603-A



PLAN
SCALE
20 10 0 20 FT

DOCUMENT MICROFILMING IDENTIFICATION

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DIST. 1 REGION

W.P. No. 260-66-07

CONT. No. 89-41
see also 81-05

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HWY. No. E.C. ROW

LOCATION MALDEN RD.

No of PAGES -

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EBL 260-66-07
DONE IN METRIC

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1.2 Miles East of Hwy. 18 - Windsor

WBL Done under 81-05

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Hwy. ECR, District 1, Chatham
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upper portion was found to be frozen at the time of the field investigation. The relative density is estimated to be compact.

Silty Clay to Clayey Silt

The silty sand is underlain by an extensive cohesive type stratum at each boring location. The lower boundary of the deposit was encountered between elevation 496 and elevation 500. It was penetrated fully only in B.H. 1 and 3. The material in the deposit consists of silty clay to clayey silt, some sand and traces of gravel. A plot of plasticity index versus liquid limit (Fig. 1) shows the points to fall within the CL and CI zones indicating a low to medium plasticity. Physical properties of the overall deposit as determined from field and laboratory tests are as follows:

Natural Moisture Content (%)	17- 29
Liquid Limit (%)	23- 41
Plastic Limit (%)	14- 21
Bulk Density (PCF)	115- 134
Unconfined Shear Strength (PSF)	600-4690
Field Vane Test (PSF)	1000-2000+
Sensitivity	1.6- 3.2

The results of mechanical analyses are shown in an envelope form on Figure 2.

The undrained shear strength of the deposit in general decreases with depth. For design purposes the following undrained shear strength values are suggested:

Above Elev. 580 - 2000 PSF
 Elev. 565-Elev. 580 - 1500 PSF
 Elev. 565-Elev. 500 - 1000 PSF

The consistency of the overall deposit ranges from firm to very stiff.

Sandy Silt

An approximate 5-10 foot thick sandy silt, some gravel zone was found to underlie the cohesive deposit. The relative density is estimated to be very dense.

Limestone Bedrock

The bedrock was proven at one borehole location (B.H. #1) by obtaining AXT size core. The bedrock was found to be sound limestone, the surface being at elevation 490±.

Groundwater Conditions

Groundwater level observations have been carried out during the course of fieldwork by recording the water levels in the open boreholes. The following groundwater levels were observed:

B.H. #1 Elev. 591

B.H. #2 Elev. 591

B.H. #3 Elev. 590

B.H. #4 Not observed

These figures indicate that the groundwater level is located some 2-3 feet below the existing ground level.

DISCUSSION AND RECOMMENDATIONS

General

It is proposed to build a three span (35'-66'-35') twin overpass structure at this location. The profile grade of E.C. Row Expressway is set at elevation 614, some 21 feet above Malden Road surface. The existing ground surface adjacent to the proposed structure site is at about elevation 593±.

Structure Foundations

It is recommended that the entire structure (abutments and piers) be founded on end bearing piles driven to bedrock. The bedrock surface is located some 95 feet below ground level. These piles could be either steel 'H' piles or concrete filled steel tube piles. Design loads could be as high as 130 tons/pile for either 12 3/4" x 1/4" steel tubes or 12BP074 steel 'H' sections. The tips of steel 'H' piles should be reinforced. If tube piling is selected the driving energy should not exceed 30,000 ft. lbs. per blow below elevation 500 to avoid damage to the pile tips when contact with the bedrock is made.

The pile caps should be protected against frost action by at least 4 feet of earth cover.

No major dewatering problems are anticipated.

Approach Embankments

The shear strength of the subsoil is such that it will be able to support the 21 foot high approach embankments constructed with 2:1 slopes. The fill should consist of well compacted acceptable material. Care should be taken to ensure that no bouldery fill is placed within the approaches through which piles have to be driven and it is recommended that this portion of the fill contain no larger grain sizes than 2 inches.

It is estimated that a maximum settlement of 4-5 inches will take place over a long period of time under the 21 foot high fill at the abutment locations. It is also estimated that 50% of the predicted settlement will be completed in about 6 months' time. To minimize the effect of the settlement on the performance of the structure it is recommended that the approaches be built in advance of the structure for as long a period as possible.

MISCELLANEOUS

The field investigation was carried out under the supervision of Mr. A.M. Seppala, Project Engineer. The equipment used was owned and operated by Canadian Longyear Ltd. This report was written by Mr. P. Payer.

P. Payer
P. Payer, P. Eng.
Senior Engineer



K. G. Selby
K.G. Selby, P. Eng.
Supervising Engineer

KGS/PP/gs
November, 1977

APPENDIX



Ministry of
Transportation and
Communications

HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 1 (Formerly B.H.5 W.O. 68-F-15-1)

W P 260-66-03

LOCATION Co-ords N 15,358,550; E 848,663

ORIGINATED BY AMS

DIST 1 HWY 5.C. Row Expwy

BOREHOLE TYPE Cont. Flight Auger (Bombardier) AXT Rock Core & Cone Test

COMPILED BY AMS

DATUM Geodetic

DATE Feb., 21 & 22, 1968

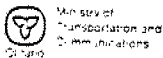
CHECKED BY RS

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 PCF	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH P.S.F.					
592.3	Ground Level													
0.0	Silty Sand													
588.8	Compact													
4.0			1	SS	5									
			2	SS	20									
			3	SS	18									
			4	SS	9									
	Silty Clay		5	TW	PH									
	To		6	TW	PH									
	Clayey Silt		7	TW	PH									
	Some Sand		8	TW	PH									
	Trace of Gravel		9	TW	PH									
	Firm to Very Stiff		10	TW	PH									
			11	TW	PM									
			12	TW	PM									
			13	TW	PM									
			14	TW	PM									
499.8														
93.0	Sandy Silt													
	Some Gravel													
490.0	Very Dense													
102.8	Limestone Bedrock		15	AXT	REC									
484.6	Sound			RC	100%									
108.2	End of Borehole													

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION



HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 2 (Formerly B.H.6 W.O. 68-F-15-1)

W P 260-66-03 LOCATION Co-ords N 15,358,662; E 848,637 ORIGINATED BY AMS
 DIST 1 Hwy E.C. Row Expwy BOREHOLE TYPE Cont. Flight Auger (Bombardier) & Cone Test COMPILED BY AMS
 DATUM Geodetic DATE Feb., 23, 1968 CHECKED BY RS

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					
593.0	Ground Level																
0.0	Silty Sand																
589.0	Compact																
4.0	Silty Clay To Clayey Silt Some Sand Trace of Gravel Firm to Very Stiff		1	SS	6												
			2	TW	PH												
			3	TW	PH												
			4	TW	PM												
			5	TW	PM												
			6	TW	PM												
			7	TW	PM												
551.5			8	TW	PM												
41.5	End of Borehole																

+3, x5: Numbers refer to
Sensitivity

20
15-5 (%) STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION



Highway Engineering Division
Engineering Materials Office - Soil Mechanics Section

HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 3 (Formerly B.H.7.K.O. 68-F-15-1)

W P 260-66-03 LOCATION Co-ords N 15,358,707; E 848,504 ORIGINATED BY AMS
 DIST 1 HWY E.C. Row Expwy BOREHOLE TYPE Cont. Flight Auger (Bombardier) & Cone Test COMPILED BY AMS
 DATUM Geodetic DATE Feb. 26 & 27, 1968 CHECKED BY RS

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	500 1000 1500 2000 2500					
592.3	Ground Level													
0.0	Silty Sand						590	Frozen Zone						
588.3	Compact													
4.0	Silty Clay To Clayey Silt Some Sand Trace of Gravel Firm To Stiff		1	SS	7								125	0 9 31 60
			2	TW	PH									
			3	SS	11								124	
			4	TW	PM									
			5	TW	PM									
			6	TW	PM								127	
			7	TW	PM									
			8	TW	PM								126	3 15 40 42
			9	TW	PM									
			10	TW	PM								115	1 19 55 25
			11	TW	PM									
			12	TW	PM								132	3 20 38 39
			13	TW	PM									
			14	TW	PM									
496.3														
96.0	Sandy Silt, Some Gravel													
491.0	Very Dense													
101.3	End of Borehole (Refusal)													

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

OFFICE REPORT ON SOIL EXPLORATION



Ministry of
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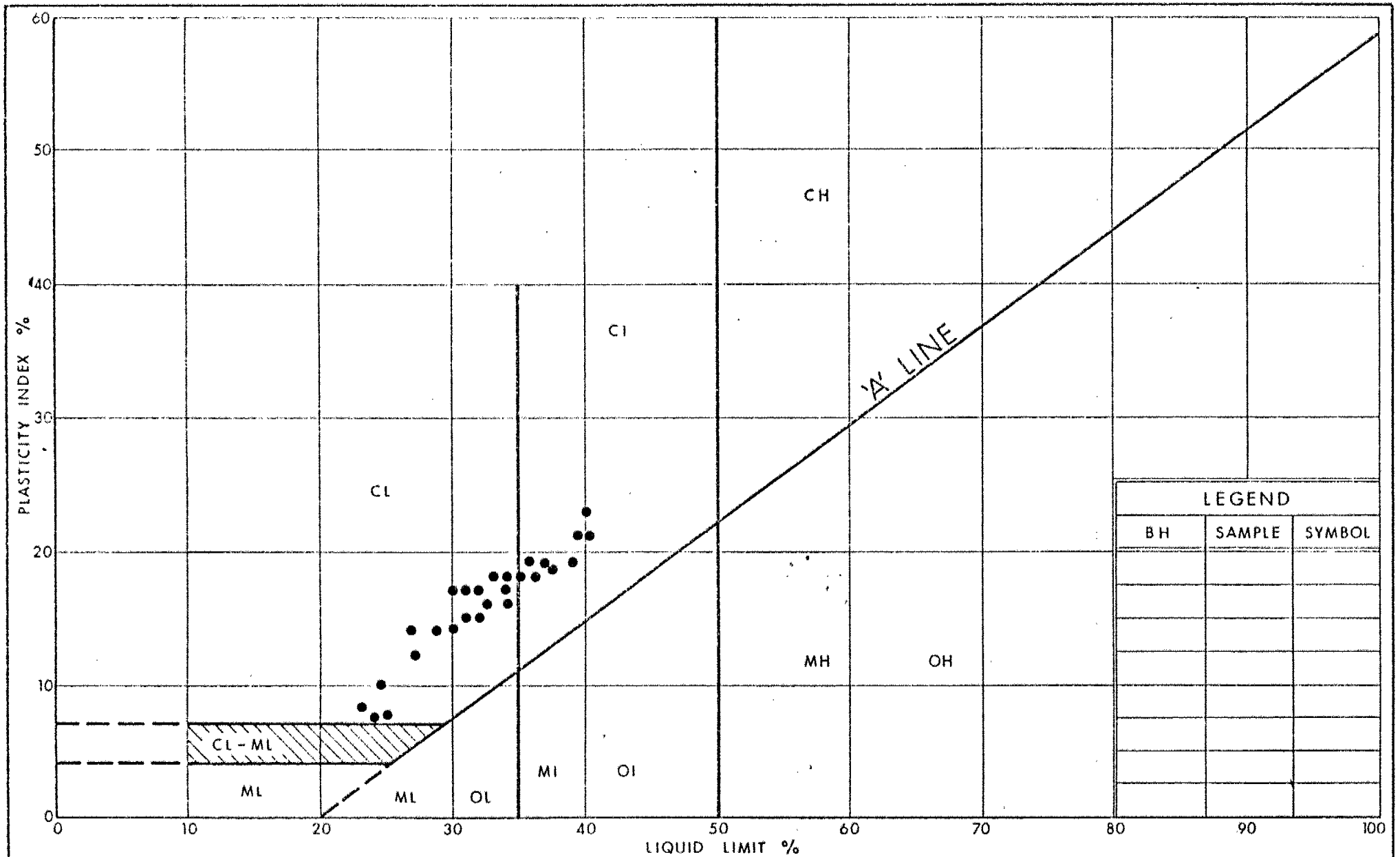
HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 4 (Formerly B.H.8 W.O. 68-F-15-1)

W P 260-66-03 LOCATION Co-ords N 15,358,594; E 848,573 ORIGINATED BY AMS
 DIST 1 HWY E.C. Row Expwy BOREHOLE TYPE Cont. Flight Auger (Bombardier) & Cone Test COMPILED BY AMS
 DATUM Geodetic DATE Feb. 27, 1968 CHECKED BY RS

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 PCF	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 500 1000 1500 2000 2500
593.6	Ground Level													
0.0	Silty Sand													
589.6	Compact													
4.0			1	SS	4									
			2	TW	PH								129	
			3	TW	PH								123	0 13 41 46
			4	TW	PH									
			5	TW	PH									
			6	TW	PH								124	
			7	TW	PH									
			8	TW	PH								127.5	1 16 44 39
550.6														
43.0	End of Borehole													
	Note Water Level Not Established													

OFFICE REPORT ON SOIL EXPLORATION



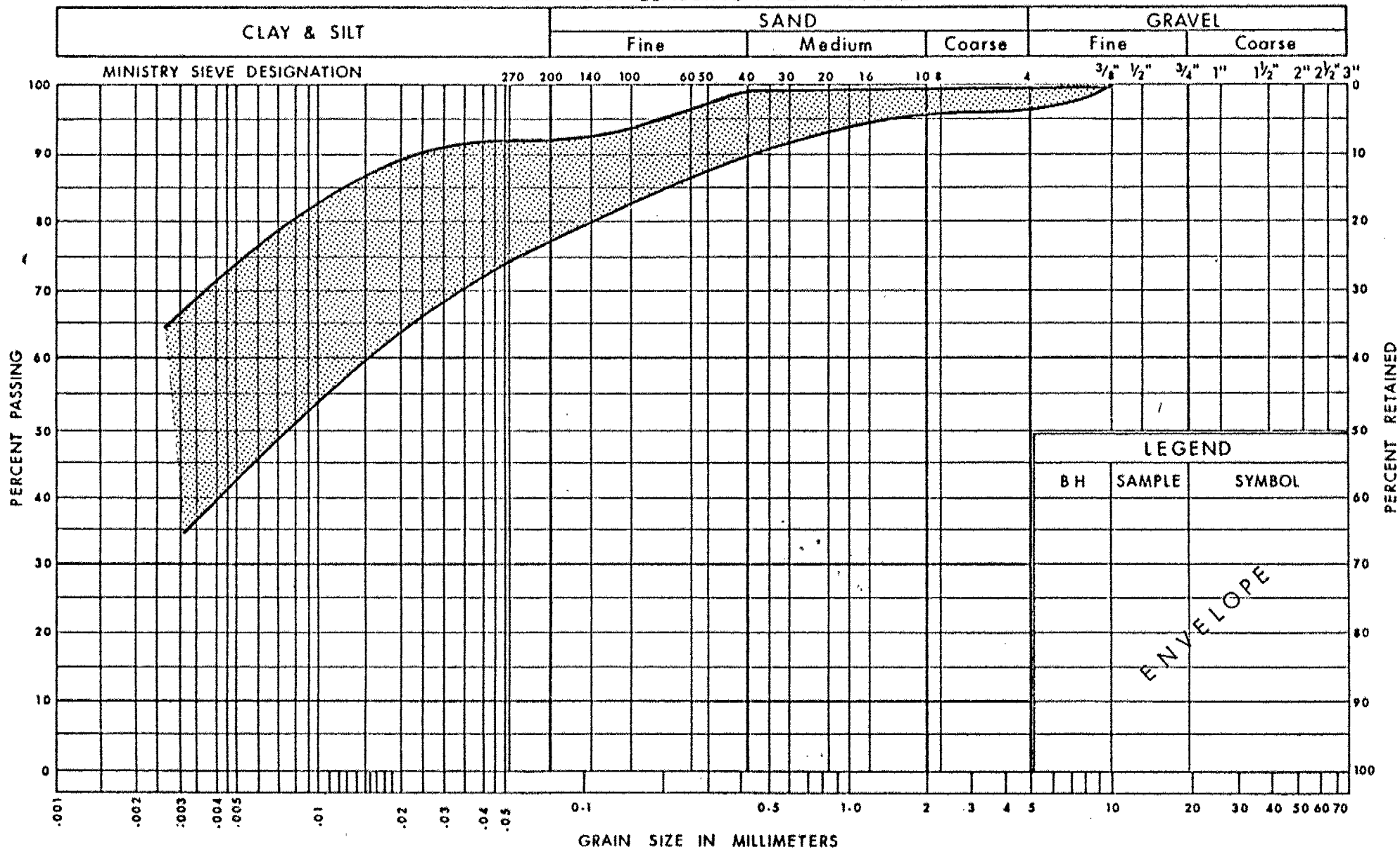
Ministry of
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Communications

PLASTICITY CHART SILTY CLAY TO CLAYEY SILT

FIG No 1

W P 260-66-03

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

 Ministry of
Transportation and
Communications

 GRAIN SIZE DISTRIBUTION
SILTY CLAY TO CLAYEY SILT

FIG No 2

WP 260 - 66 - 03

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. A119.2): CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (2" O.D. 60 CONE ANGLE) DRIVEN BY 350 FT-LB IMPACTS ON 1" 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

S S SPLIT SPOON
W S WASH SAMPLE
S T SLOTTED TUBE SAMPLE
B S BLOCK SAMPLE
C S CHUNK SAMPLE
T W THINWALL OPEN
T P THINWALL PISTON
O S OSTERBERG SAMPLE
F S FOIL SAMPLE
R C ROCK CORE
P H T.W. ADVANCED HYDRAULICALLY
P M T.W. ADVANCED MANUALLY

EARTH PRESSURE TERMS

μ COEFFICIENT OF FRICTION
 δ 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
 β ANGLE OF SLOPE
 N, N_q, N_c BEARING CAPACITY FACTORS
 D_f DEPTH OF FOOTING
 B, L FOOTING DIMENSIONS

INDEX PROPERTIES

γ UNIT WEIGHT OF SOIL (BULK DENSITY)
 γ_w UNIT WEIGHT OF WATER
 γ_d UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
 γ' 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 = $\frac{I_p \text{ of soil}}{w_L - w_p \text{ of soil fraction}}$
 Om ORGANIC MATTER CONTENT
 S_c DEGREE OF SATURATION
 S SENSITIVITY = $\frac{S_u(\text{undisturbed})}{S_u(\text{remolded})}$

STRENGTH PARAMETERS

ϕ ANGLE OF SHEARING RESISTANCE
 τ_f PEAK SHEAR STRENGTH
 τ_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
 ϵ LINEAR STRAIN
 γ SHEAR STRAIN
 ν 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
 η 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_o COMPRESSION INDEX
 C_r RECOMPRESSION INDEX
 d DRAINAGE PATH DISTANCE
 T_v TIME FACTOR
 U DEGREE OF CONSOLIDATION
 O_c OVERCONSOLIDATION RATIO (OCR)

NOTE: EFFECTIVE STRESS PARAMETERS ARE DENOTED BY USE OF APOSTROPHE ABOVE THE SYMBOL, THUS:
 σ' = EFFECTIVE ANGLE OF SHEARING RESISTANCE;
 σ' = EFFECTIVE NORMAL STRESS

