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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

FOUNDATION INVESTIGATION REPORT

CONTRACT NO 87-37

Ontario

Ministry of
Transportation and
Communications

40J6-13

INDEX

NOTE: For purposes of the contract, this report supercedes all other foundation reports prepared by or for the Ministry in connection with the above-noted project.

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 $\bar{N}$.

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:

C_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. $\overline{CIU}$ = 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
F 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_γ, 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 = $\frac{w - w_p}{I_p}$
I_c	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
A_c	ACTIVITY = $\frac{I_p \text{ of soil}}{\%\text{ of } 2\mu m \text{ Soil Fraction}}$
Om	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
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

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

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_r	OVERCONSOLIDATION RATIO (OCR)

EXTENDED CASAGRANDE SOIL CLASSIFICATION SYSTEM

FIELD IDENTIFICATION PROCEDURES

(EXCLUDING PARTICLES LARGER THAN 75 mm AND BASING FRACTIONS ON ESTIMATED MASS)

				GRP SYMP	TYPICAL NAMES
COARSE GRAINED SOILS (MORE THAN HALF OF MATERIAL IS LARGER THAN 75 μm)	GRAVELS (MORE THAN HALF OF COARSE FRACTION IS LARGER THAN 4.75 mm)	CLEAN GRAVELS (LITTLE OR NO FINES)	WIDE RANGE IN GRAIN SIZE & SUBSTANTIAL AMOUNTS OF ALL INTERMEDIATE PARTICLE SIZE	GW	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES; LITTLE OR NO FINES
			PREDOMINANTLY ONE SIZE OF A RANGE OF SIZES WITH SOME INTERMEDIATE SIZES MISSING	GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES; LITTLE OR NO FINES
		GRAVEL WITH FINES (APPRECIABLE AMOUNT OF FINES)	NON-PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE ML BELOW)	GM	SILTY GRAVELS, POORLY GRADED GRAVEL-SAND-SILT MIXTURES
			PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE CL BELOW)	GC	CLAYEY GRAVELS, POORLY GRADED GRAVEL-SAND-CLAY MIXTURES
	SANDS (MORE THAN HALF OF COARSE FRACTION IS SMALLER THAN 4.75 mm)	CLEAN SANDS (LITTLE OR NO FINES)	WIDE RANGE IN GRAIN SIZES & SUBSTANTIAL AMOUNTS OF ALL INTERMEDIATE PARTICLE SIZES	SW	WELL GRADED SANDS, GRAVELLY SANDS; LITTLE OR NO FINES
			PREDOMINANTLY ONE SIZE OR A RANGE OF SIZES WITH SOME INTERMEDIATE SIZES MISSING	SP	POORLY GRADED SANDS, GRAVELLY SANDS: LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	NON-PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE ML BELOW)	SM	SILTY SANDS, POORLY GRADED SAND-SILT MIXTURES
			PLASTIC-FINES (FOR IDENTIFICATION PROCEDURES SEE CL BELOW)	SC	CLAYEY SANDS, POORLY GRADED SAND-CLAY MIXTURES
FINE GRAINED SOILS (MORE THAN HALF OF MATERIAL IS SMALLER THAN 75 μm (I.75 μm IS ABOUT THE SMALLEST PARTICLE VISIBLE TO THE NAKED EYE))	IDENTIFICATION PROCEDURES ON FRACTION SMALLER THAN 425 μm				
	SILTS AND CLAYS — LIQUID LIMIT LESS THAN 35%	DRY STRENGTH (CRUSHING CHARACTERISTICS)	DILATANCY (REACTION TO SHAKING)	TOUGHNESS (CONSISTENCY NEAR PLASTIC LIMIT)	
		NONE	QUICK	NONE	ML — INORGANIC SILTS & SANDY SILTS OF SLIGHT PLASTICITY, ROCK FLOUR
		MEDIUM TO HIGH	NONE TO VERY SLOW	MEDIUM	CL — CLAYEY SILTS (INORGANIC), GRAVELLY CLAYS, SANDY CLAYS, LEAN CLAYS
		SLIGHT TO MEDIUM	SLOW	SLIGHT	OL — ORGANIC SILT OF LOW PLASTICITY, ORGANIC SANDY SILTS
	SILTS AND CLAYS — LIQUID LIMIT BETWEEN 35% AND 50%	NONE TO SLIGHT	SLOW TO QUICK	SLIGHT	MI — INORGANIC COMPRESSIBLE FINE SANDY SILT WITH CLAY OF MEDIUM PLASTICITY, CLAYEY SILTS
		HIGH	NONE	MEDIUM TO HIGH	CI — SILTY CLAYS (INORGANIC) OF MEDIUM PLASTICITY
		SLIGHT TO MEDIUM	VERY SLOW	SLIGHT	OI — ORGANIC SILTY CLAYS OF MEDIUM PLASTICITY
	SILTS AND CLAYS — LIQUID LIMIT GREATER THAN 50%	SLIGHT TO MEDIUM	SLOW TO NONE	MEDIUM	MH — INORGANIC SILTS, HIGHLY COMPRESSIBLE MICACEOUS OR DIATOMACEOUS FINE SANDY SILTS, ELASTIC SILTS
		HIGH TO VERY HIGH	NONE	HIGH	CH — CLAYS (INORGANIC) OF HIGH PLASTICITY, FAT CLAYS
		MEDIUM TO HIGH	NONE TO VERY SLOW	SLIGHT TO MEDIUM	OH — ORGANIC CLAYS OF HIGH PLASTICITY
HIGHLY ORGANIC SOILS		READILY IDENTIFIED BY COLOUR, ODOUR, SPONGY FEEL & FREQUENTLY BY FIBROUS TEXTURE		PT	PEAT & OTHER HIGHLY ORGANIC SOILS

INFORMATION REQUIRED FOR DESCRIBING SOILS

GIVE TYPE; NAME, IF NECESSARY; INDICATE APPROX. % OF SAND & GRAVEL; MAX. SIZE; ANGULARITY, SURFACE CONDITION, & HARDNESS OF THE COARSE GRAINS; LOCAL OR GEOLOGIC NAME & OTHER PERTINENT DESCRIPTIVE INFORMATION; & SYMBOL IN PARENTHESIS.

FOR UNDISTURBED SOILS ADD INFORMATION ON STRATIFICATION, DEGREE OF COMPACTNESS, CEMENTATION, MOISTURE CONDITIONS & DRAINAGE CHARACTERISTICS.

GIVE TYPE; NAME, IF NECESSARY, INDICATE DEGREE & CHARACTER OF PLASTICITY, AMOUNT & MAXIMUM SIZE OF COARSE GRAINS, COLOUR IN WET CONDITION, ODOUR, IF ANY, LOCAL OR GEOLOGIC NAME & OTHER PERTINENT DESCRIPTIVE INFORMATION & SYMBOL IN PARENTHESIS.

FOR UNDISTURBED SOILS ADD INFORMATION ON STRUCTURE, STRATIFICATION, CONSISTENCY IN UNDISTURBED & REMOULDED STATES, MOISTURE & DRAINAGE CONDITIONS.

USE GRAIN SIZE CURVE IN IDENTIFYING THE FRACTIONS AS GIVEN UNDER FIELD IDENTIFICATION

LABORATORY CLASSIFICATION CRITERIA

DETERMINE PERCENTAGES OF GRAVEL & SAND FROM GRAIN SIZE CURVE. DEPENDING ON PERCENTAGE OF FINES (FRACTION SMALLER THAN 75 μm) COARSE GRAINED SOILS ARE CLASSIFIED AS FOLLOWS:

LESS THAN 5%	GW, GP, SW, SP
MORE THAN 12%	GM, GC, SM, SC
5% TO 12%	BORDERLINE CASES REQ. USE OF DUAL SYMBOLS

$C_U = \frac{D_{60}}{D_{10}}$ GREATER THAN 4

$C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ BETWEEN ONE AND 3

NOT MEETING ALL GRADATION REQUIREMENTS FOR GW

ATTERBERG LIMITS BELOW A-LINE, OR I_p LESS THAN 4

ATTERBERG LIMITS ABOVE A-LINE WITH I_p GREATER THAN 7

ABOVE A-LINE WITH I_p BETWEEN 4 AND 7 ARE BORDERLINE CASES REQUIRING USE OF DUAL SYMBOLS

$C_U = \frac{D_{60}}{D_{10}}$ GREATER THAN 6

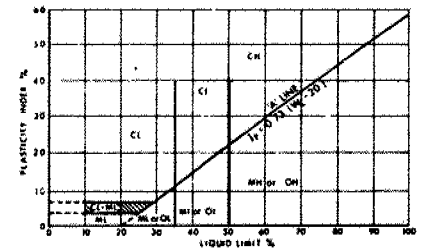
$C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ BETWEEN ONE AND 3

NOT MEETING ALL GRADATION REQUIREMENTS FOR SW

ATTERBERG LIMITS BELOW A-LINE OR I_p LESS THAN 4

ATTERBERG LIMITS ABOVE A-LINE WITH I_p GREATER THAN 7

ABOVE A-LINE WITH I_p BETWEEN 4 AND 7 ARE BORDERLINE CASES REQUIRING USE OF DUAL SYMBOLS



PLASTICITY CHART
FOR LABORATORY CLASSIFICATION OF FINE GRAINED SOILS

BOUNDARY CLASSIFICATIONS: SOILS POSSESSING CHARACTERISTICS OF TWO GROUPS ARE DESIGNATED BY COMBINATIONS OF GROUP SYMBOLS. FOR EXAMPLE GW-GC, WELL GRADED GRAVEL-SAND MIXTURE WITH CLAY BINDER

INTRODUCTION

This report contains the results of a foundation investigation carried out for the proposed overpass structure during the period from March 12 to 15, 1968. A muskeg vehicle mounted power auger machine equipped with solid augers was used to advance four boreholes to depths ranging from 43 to 119 feet in depth. Dynamic Cone Penetration Tests were carried out adjacent to two boreholes.

SITE DESCRIPTION

The site is located 2.5 miles east of Hwy. 18 along the proposed E.C. Row Expressway alignment within the City of Windsor. The surrounding terrain is flat.

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 deep deposit of clayey silt containing some sand and a trace of gravel, followed by a sandy silt, some gravel 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 No. 2 of the Contract Drawings are based upon this information. The different strata encountered from ground level downward are described in some detail as follows.

Clayey Silt, Some Sand, Traces of Gravel

Immediately below the ground surface an extensive, cohesive type deposit was encountered at each boring location. The lower boundary was found to be at elevation 483.5±. It was penetrated fully only in BH 1. The material in the deposit consists of clayey silt containing some sand and a trace of gravel.

Occasional silty clay layers and seams of silt were also encountered. A plot of plasticity index versus liquid limit shows the greater majority of points to fall within the CL zone indicating a low to medium plasticity (Figure 1). Physical properties of the overall deposit as determined from field and laboratory tests are as follows:

			Range
Natural Moisture Content	(W)	%	11-24
Liquid Limit	(W_L)	%	20-37
Plastic Limit	(W_p)	%	12-18
Bulk Density	(Y)	PCF	131-140
Undrained Shear Strength	(Cu)	PSF	
Unconfined			819-2730
Field Vane			1040-2000+
Sensitivity			2-4

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

A desiccated zone with a thickness ranging from 8 to 10 feet was found in all the boreholes to extend from Elev. 598± downward. This zone is brown in colour due to oxidation and/or weathering and has a very stiff consistency. Standard Penetration 'N' values ranged from 15 to 48 blows per foot.

Below the desiccated layer the colour of the soil is grey and the consistency ranges somewhat randomly from firm to very stiff. The obtained undrained shear strength values (unconfined and field vane tests) versus depth (elevation) are shown on Figure 3 of the Appendix. The average values of the shear strength are as follows:

Elev. 598 - Elev. 589:	Cu = 4000 PSF
Elev. 589 - Elev. 580:	2500
Elev. 580 - Elev. 570:	1500
Elev. 570 - Elev. 492:	1100

Sandy Silt, Some Gravel

An approximate 9 foot thick sandy silt containing some gravel zone was found to underlie the cohesive deposit. The relative density is estimated to vary from compact to dense.

Bedrock

The bedrock surface is believed to be Elev. 483.5, based on refusal to further penetration of the augers, since no core samples were taken at this location. Field investigations carried out within 1.0 mile east and west of this project indicated limestone type bedrock.

Groundwater Conditions

No groundwater observations were carried out during the field investigation. It is estimated that the water level is some 2-3 feet below the ground surface. It is assumed that the groundwater levels are subjected to seasonal variation.

P. Payer, P.Eng.
Senior Foundations Engineer

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

APPENDIX

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 2

W P 258-66-03 LOCATION Co-ords. 15,359,305 N 856,822 E ORIGINATED BY AMS
DIST 1 HWY E.C. Row Expry BOREHOLE TYPE Cont. Flight auger (bombardier) & Cone COMPILED BY AMS
DATUM Geodetic DATE March 13, 1968 CHECKED BY

SOIL PROFILE ELEV/DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH P.S.F. ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 500 1000 1500 2000 2500	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ P.C.F.	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
602.6	Ground Level										
0.0							600				
			1	SS	36						3 28 42 27
	Clayey Silt		2	SS	43						
							590				
	Some Sand		3	TW	PH					138	
	Trace of Gravel		4	TW	PH						
							580				
			5	TW	PH					136	
	Firm to Hard		6	TW	PH						
							570				
			7	TW	PH					140	3 31 51 15
			8	TW	PH						
							560				
549.6			9	TW	PH		550			132	
53.0	End of Borehole										
	W.L. Not Observed										

$+^3$, $\times^5$: Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No 3

W P 258-66-03 LOCATION Co-ords. 15,359,267 N 856,665 E ORIGINATED BY AMS
DIST 1 HWY E.C. Row Expry BOREHOLE TYPE Cont. flight auger (bombardier) COMPILED BY AMS
DATUM Geodetic DATE March 14, 1968 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) SHEAR STRENGTH P.S.F. ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE (500 1000 1500 2000 2500)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ P.C.F.	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
603.0	Ground Level										
0.0							600				
			1	SS	18						
	Clayey Silt Some Sand		2	SS	48		590				2 31 44 23
	Trace of Gravel Very Stiff to Hard		3	SS	16						
			4	TW	PH		580	>+			
			5	TW	PH			+2		137	
			6	TW	PH			+2			
			7	TW	PH		570	+2		136	
			8	TW	PH			+2		137	2 31 44 23
			9	TW	PH		560	+2			
			10	TW	PH			+2		133	
			11	TW	PH		550	+2			
			12	TW	PH		540	+3		131	
			13	TW	PH		530	+2			
			14	SS	29		520				2 21 47 30
			15	SS	24		510				
493.3							500				
109.7	End of Borehole W.L. Not Observed										

+3, ×5 : Numbers refer to Sensitivity

15 ◇ 20 10 S (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No 4

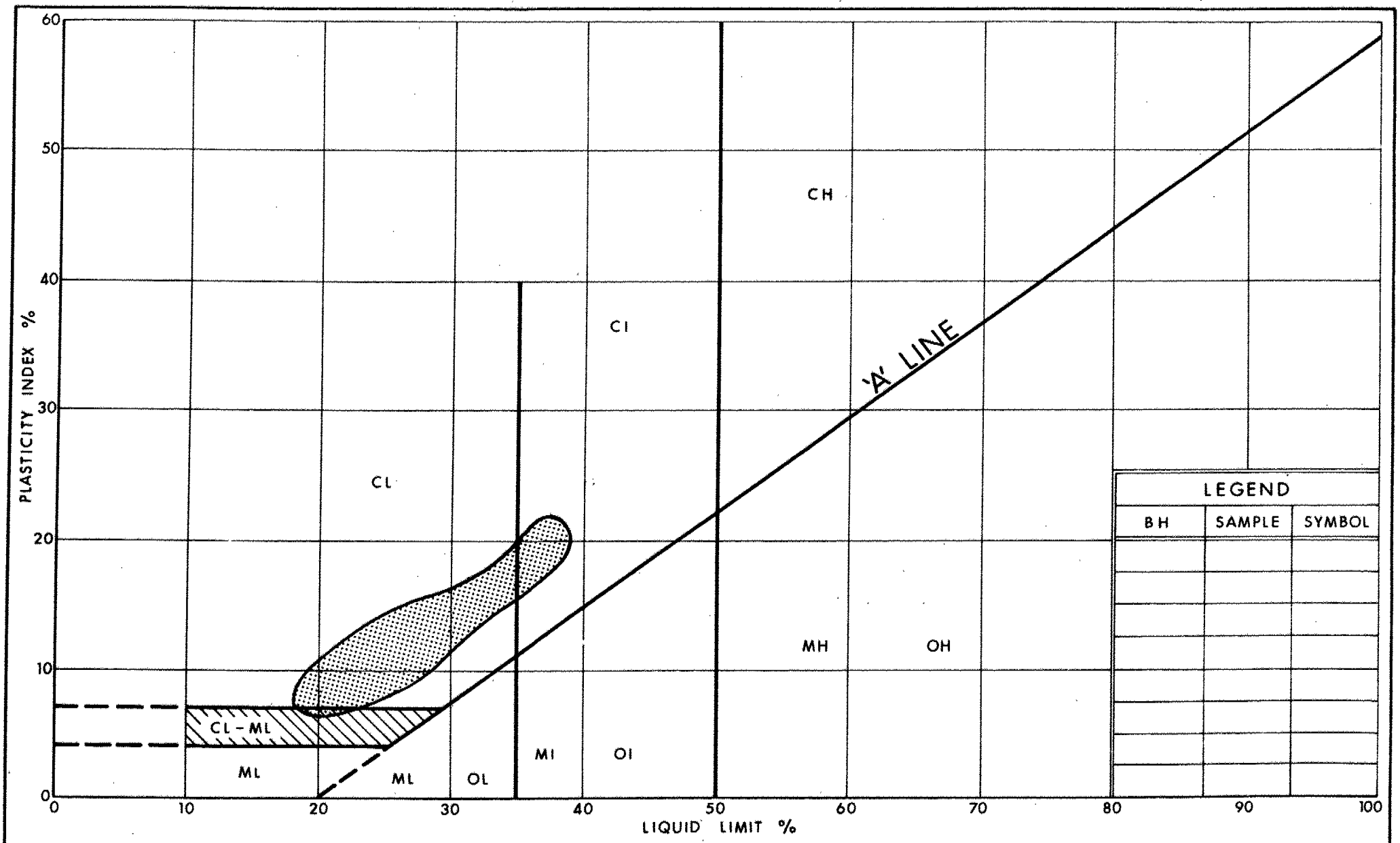
W P 258-66-03 LOCATION Co-ords. 15,359,409 N 856,600 E ORIGINATED BY AMS
DIST 1 HWY E.C. Row Expry BOREHOLE TYPE Cont. Flight auger (bombardier) COMPILED BY AMS
DATUM Geodetic DATE March 15, 1968 CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH P.S.F. (o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, x LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL / WATER CONTENT (%)	UNIT WEIGHT γ P.C.F.	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
603.0	Ground Level							20 40 60 80 100 / 500 1000 1500 2000 2500	10 20 30		
0.0							600				
			1	SS	15						1 28 45 26
	Clayey Silt		2	SS	48						
							590				
	Some Sand		3	TW	18						
	Trace of Gravel		4	TW	PH					136	
	Firm to Hard						580				
			5	TW	PH						
			6	TW	PH					136	2 30 38 30
							570				
			7	TW	PH						
			8	TW	PH					133	
560.0											
43.0	End of Borehole						560				
	W.L. Not Observed										

+3, x5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION



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PLASTICITY CHART
CLAYEY SILT
SOME SAND, TRACE OF GRAVEL

FIG No 1

W P 258-66-03

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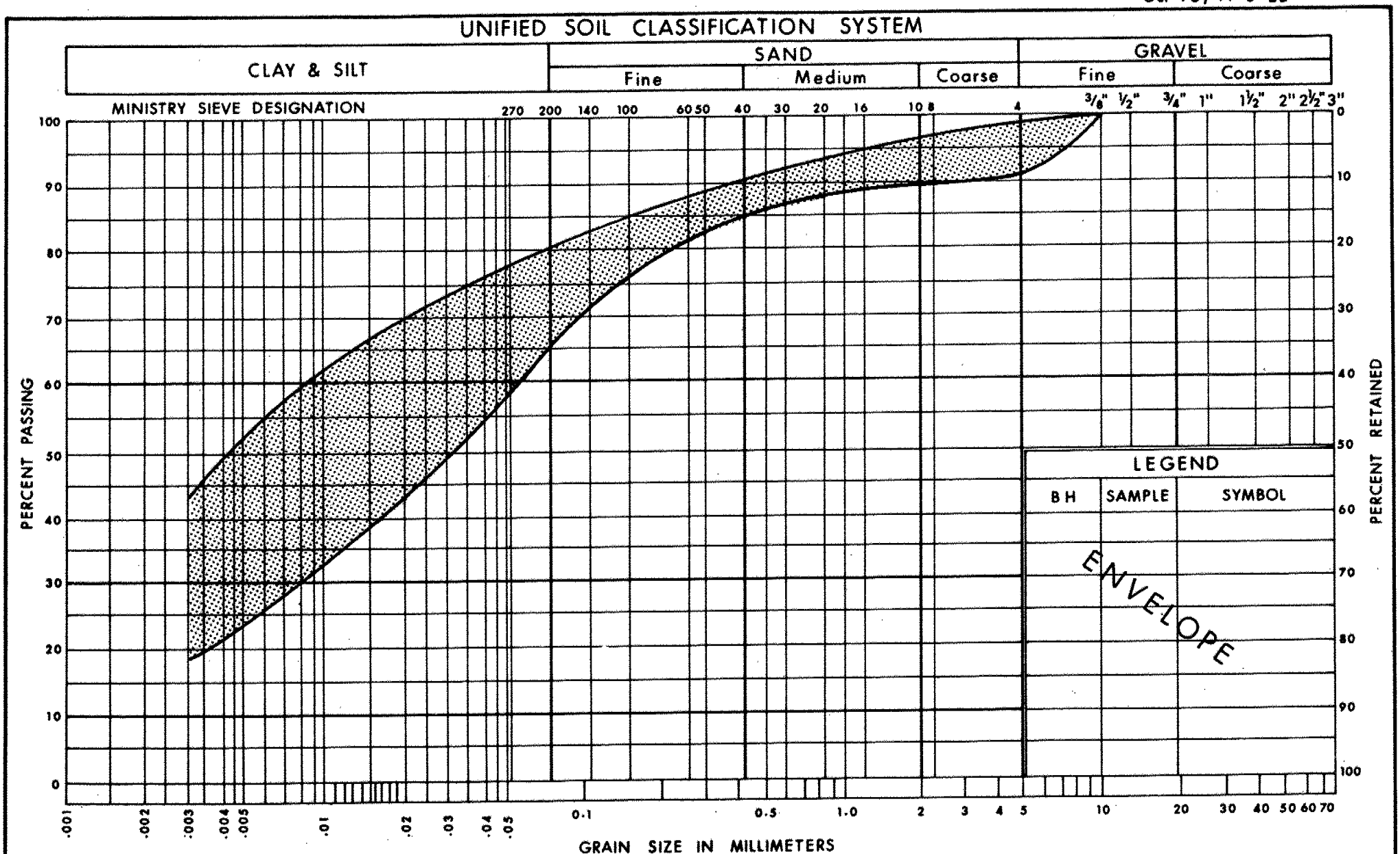

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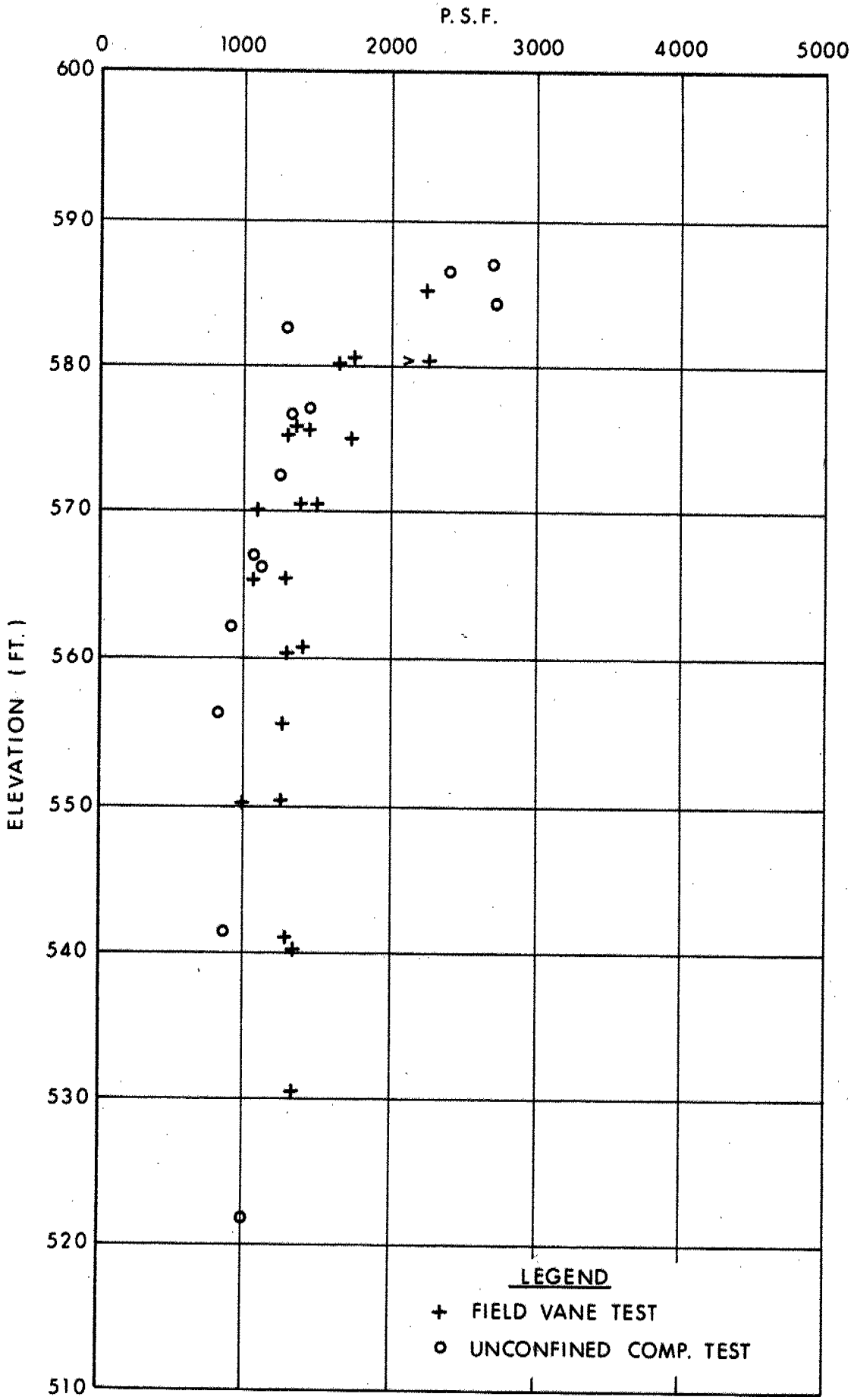
GRAIN SIZE DISTRIBUTION
CLAYEY SILT
SOME SAND, TRACE OF GRAVEL

FIG No 2
WP 258-66-03

13



SHEAR STRENGTH Vs ELEVATION

FIG. 3

W.P. 258-66-03

ENGINEERING MATERIALS OFFICE
PAVEMENT & FOUNDATION DESIGN SECTION

WP 258-66-03 DIST 1

HWY E.C.R. STR SITE 6-1398-284

Windsor - Dominion Blvd. Overpass

DISTRIBUTION

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GEOCRES 40J6-13

DATE SEP 13 1982

FOUNDATION INVESTIGATION REPORT

For

Windsor - Dominion Blvd. Overpass
Hwy. E.C.R., District 1, Chatham
W.P. 258-66-03, Site 6-1398-284

INTRODUCTION

This report contains the results of a foundation investigation carried out for the proposed overpass structure during the period from March 12 to 15, 1968. A muskeg vehicle mounted power auger machine equipped with solid augers was used to advance four boreholes to depths ranging from 43 to 119 feet in depth. Dynamic Cone Penetration Tests were carried out adjacent to two boreholes.

SITE DESCRIPTION

The site is located 2.5 miles east of Hwy. 18 along the proposed E.C. Row Expressway alignment within the City of Windsor. The surrounding terrain is flat.

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 deep deposit of clayey silt containing some sand and a trace of gravel, followed by a sandy silt, some gravel 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 No. 2586603-A are based upon this information. The different strata encountered from ground level downward are described in some detail as follows:

Clayey Silt, Some Sand, Traces of Gravel

Immediately below the ground surface an extensive, cohesive type deposit was encountered at each boring location. The lower boundary was found to be at elevation 483.5±. It was penetrated fully only in B.H. #1. The material in the deposit consists of clayey silt containing some sand and a trace of gravel. Occasional silty clay layers and seams of silt were also encountered. A plot of plasticity index versus liquid limit shows the greater majority of points to fall within the CL zone indicating a low to medium plasticity (Figure 1). Physical properties of the overall deposit as determined from field and laboratory tests are as follows.

		Range
Natural Moisture Content	(W) %	11-24
Liquid Limit	(W_L) %	20-37
Plastic Limit	(W_P) %	12-18
Bulk Density	(γ) PCF	131-140
Undrained Shear Strength	(Cu) PSF	
Unconfined		819-2730
Field Vane		1040-2000+
Sensitivity		2-4

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

A desiccated zone with a thickness ranging from 8 to 10 feet was found in all the boreholes to extend from El. 598± downward. This zone is brown in colour due to oxidation and/or weathering and has a very stiff to hard consistency. Standard penetration "N" values ranged from 15 to 48 blows per foot.

Below the desiccated layer the colour of the soil is grey and the consistency ranges somewhat randomly from firm to very stiff. The obtained undrained shear strength values (unconfined and field vane tests) versus depth (elevation) are shown on Figure 3 of the Appendix. For design purposes the following undrained shear strength values are suggested:

El. 598 - El. 589; Cu = 4000 PSF
El. 589 - El. 580; Cu = 2500 PSF
El. 580 - El. 570; Cu = 1500 PSF
El. 570 - El. 492; Cu = 1100 PSF

Sandy Silt, Some Gravel

An approximate 9 foot thick sandy silt containing some gravel zone was found to underlie the cohesive deposit. The relative density is estimated to vary from compact to dense.

Bedrock

The bedrock surface is believed to be at El. 483.5, based on refusal to further penetration of the augers, since no core samples were taken at this location. Field investigations carried out within 1.0 mile east and west of this project, indicated limestone type bedrock.

Groundwater Conditions

No groundwater observations were carried out during the field investigation. It is estimated that the water level is some 2-3 feet below the ground surface.

Discussion and Recommendations

It is proposed to build a two span (77' -77') twin overpass structure at this location. The profile grade of E.C. Row Expressway is set at El. 623± some 21 feet above the surface of Dominion Blvd.

Structure Foundations

Piled 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 119 feet below ground level. These piles could be either steel 'H' piles or concrete filled steel tube piles. 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 piles when contact with bedrock is made.

For the purposes of the O.H.B.D.C. the following design values are recommended:

	12 BP @ 74	12 BP @ 53
Factored Capacity at U.L.S.	180 tons	95 tons
Capacity at S.L.S. Type II	130 tons	70 tons

Steel Tube Piles (12 3/4" X 1/4")

Factored Capacity at U.L.S.	180 tons
Capacity at S.L.S. Type II	130 tons

Earth pressures should be computed as per subsection 6.6.1.2.2 of the code. For the granular backfill (non-yielding foundation) a value of $K_o = 0.5$ is recommended.

Spread Footings

The entire structure may be supported on spread footings placed within the original subsoil between elevation 591 and elevation 595. The following design values are recommended:

Factored Bearing Capacity at U.L.S.	3.25 TSF
Bearing Capacity at S.L.S. Type II	2.50 TSF

Earth pressures should be computed as per subsection 6.6.1.2.2 of the O.H.B.D.C. assuming a yielding foundation condition with $K_A = 0.33$ for granular backfill.

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. It is recommended that this portion of the fill contain no larger grain size than 2 inches if steel tube piles are considered or larger than 3 inches in the case of steel 'H' piles.

Settlement Considerations

Due to the compressible nature of the predominant subsoil (clayey silt), it is inevitable that consolidation settlements will occur over a long-term period due to the imposed loads of structure abutments on spread footings and embankments. 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. Based on the experiences with similar structures under similar subsoil conditions, it can be concluded that 50% of the total settlement will be completed in about 6 months' time.

For piers, it is estimated that settlements of spread footings will be in the order of 1½ to 2 inches. Thus, differential settlements up to 3½ inches between the piers and abutments if supported on spread footings are anticipated. Regardless of whether the structure is wholly or partly on spread footings, it would be advantageous to construct the embankments well in advance of the structures in order to minimize future differential settlements. Consideration should also be given to surcharging at the abutments' location if spread footing type support is used. The aforementioned granular core should be placed first and earth fill could be placed up to the grade of surcharge level.

Other Considerations

The pile caps and/or the underside of the spread footings should be protected against frost penetration with a minimum cover of 4 feet.

The topsoil stripping should be in accordance with current M.T.C. standards.

No major dewatering problems are anticipated.

Should the piles be driven closer than 12 feet from underground utilities, preboring to a minimum depth of 6 feet below such utilities is recommended.

Miscellaneous

The boring program was carried out during the period of March 12-15, 1968 under the supervision of Mr. A.M. Seppala, Project Engineer.

The equipment used was owned and operated by Canadian Longyear Ltd. This report was prepared by P. Payer and reviewed by Mr. K.G. Selby.

D. H. Dundas
for
P. Payer, P. Eng.
Foundations Engineer

K. G. Selby

K.G. Selby, P. Eng.
Senior Foundations Engineer

APPENDIX

Ministry of Transportation and Communications
Ontario

RECORD OF BOREHOLE No 1

W P 258-66-03 LOCATION Co-ords. 15,359,425 N 856,768 E ORIGINATED BY AMS
DIST 1 HWY E.C. Row Expry. BOREHOLE TYPE Cont. flight auger (bombardier) & cone COMPILED BY AMS
DATUM Geodetic DATE March 12 & 13, 1968 CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ P.C.F.	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
602.5 / 0.0	Ground Level								
	Clayey Silt Some Sand Traces of Gravel Firm to Hard		1	SS	38		600		W.L. not observed
			2	SS	32				3 30 41 26
			3	TW	PH		590	138	
			4	TW	PH				
			5	TW	PH		580	134	
			6	TW	PH				
			7	TW	PH		570	135	
			8	TW	PH				
			9	TW	PH		560	135	1 29 43 27
			10	TW	PH				
			11	TW	PH		550	131	
			12	TW	PH		540		
			13	TW	PH		530	137	
			14	SS	22		520		
			15	SS	16		510		9 12 45 34
492.5							500		
110.0	Sandy Silt Some Gravel Compact to Dense						490		
483.5									

119.0 End of Borehole
Refusal Probable Bedrock

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH P.S.F.
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
500 1000 1500 2000 2500

PLASTIC LIMIT Wp — NATURAL MOISTURE CONTENT W — LIQUID LIMIT Wl
WATER CONTENT (%) 10 20 30

+3, ×5 : Numbers refer to Sensitivity

20
15 ◇ 5 (%) STRAIN AT FAILURE
10

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Ontario

RECORD OF BOREHOLE No 2

W P 258-66-03 LOCATION Co-ords. 15,359,305 N 856,822 E ORIGINATED BY AMS
DIST 1 HWY E.C. Row Expry BOREHOLE TYPE Cont. Flight auger (bombardier) & Cone COMPILED BY AMS
DATUM Geodetic DATE March 13, 1968 CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH P.S.F. (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE; 500 1000 1500 2000 2500)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ P.C.F.	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
602.6	Ground Level										
0.0							600				
			1	SS	36						3 28 42 27
	Clayey Silt		2	SS	43		590				
	Some Sand		3	TW	PH					138	
	Trace of Gravel		4	TW	PH		580				
			5	TW	PH			+2		136	
	Firm to Hard		6	TW	PH		570	+2			
			7	TW	PH					140	3 31 51 15
			8	TW	PH		560	+2			
549.6			9	TW	PH		550	+2		132	
53.0	End of Borehole										
	W.L. Not Observed										

$+^3$, $\times^5$: Numbers refer to Sensitivity

20 / 15 ◇ 5 (%) STRAIN AT FAILURE / 10

OFFICE REPORT ON SOIL EXPLORATION

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RECORD OF BOREHOLE No 3

W P 258-66-03 LOCATION Co-ords. 15,359,267 N 856,665 E ORIGINATED BY AMS
DIST 1 HWY E.C. Row Expry BOREHOLE TYPE Cont. flight auger (bombardier) COMPILED BY AMS
DATUM Geodetic DATE March 14, 1968 CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH P.S.F. (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT WL / WATER CONTENT (%)	UNIT WEIGHT γ P.C.F.	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
0.0 603.0	Ground Level						600				
			1	SS	18						
	Clayey Silt Some Sand		2	SS	48		590				2 31 44 23
	Trace of Gravel Very Stiff to Hard		3	SS	16						
			4	TW	PH		580				
			5	TW	PH					137	
			6	TW	PH		570				
			7	TW	PH					136	
			8	TW	PH		560			137	2 31 44 23
			9	TW	PH						
			10	TW	PH		550			133	
			11	TW	PH		540				
			12	TW	PH		530			131	
			13	TW	PH		520				
			14	SS	29		510				2 21 47 30
			15	SS	24		500				
493.3 109.7	End of Borehole W.L. Not Observed										

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No 4

W P 258-66-03 LOCATION Co-ords. 15,359,409 N 856,600 E ORIGINATED BY AMS
DIST 1 HWY E.C. Row Expry BOREHOLE TYPE Cont. Flight auger (bombardier) COMPILED BY AMS
DATUM Geodetic DATE March 15, 1968 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH P.S.F. (o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 500 1000 1500 2000 2500)	PLASTIC LIMIT Wp / NATURAL MOISTURE CONTENT W / LIQUID LIMIT Wl; WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ P.C.F.	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
603.0	Ground Level										
0.0							600				
			1	SS	15						1 28 45 26
	Clayey Silt		2	SS	48						
							590				
	Some Sand		3	TW	18						
	Trace of Gravel		4	TW	PH					136	
	Firm to Hard						580				
			5	TW	PH						
			6	TW	PH					136	2 30 38 30
							570				
			7	TW	PH						
560.0			8	TW	PH					133	
43.0	End of Borehole						560				
	W.L. Not Observed										

OFFICE REPORT ON SOIL EXPLORATION

+3, ×5 : Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

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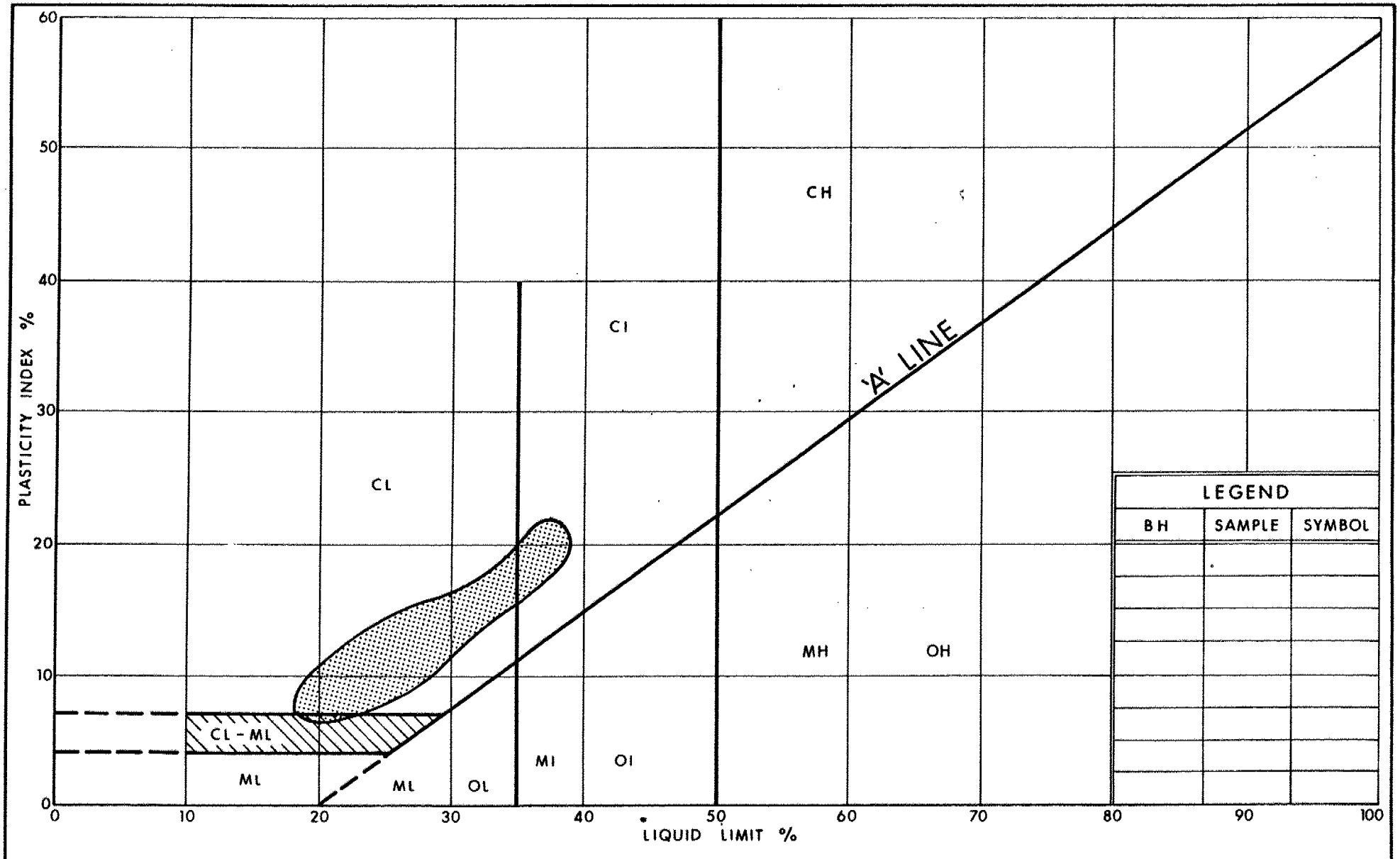

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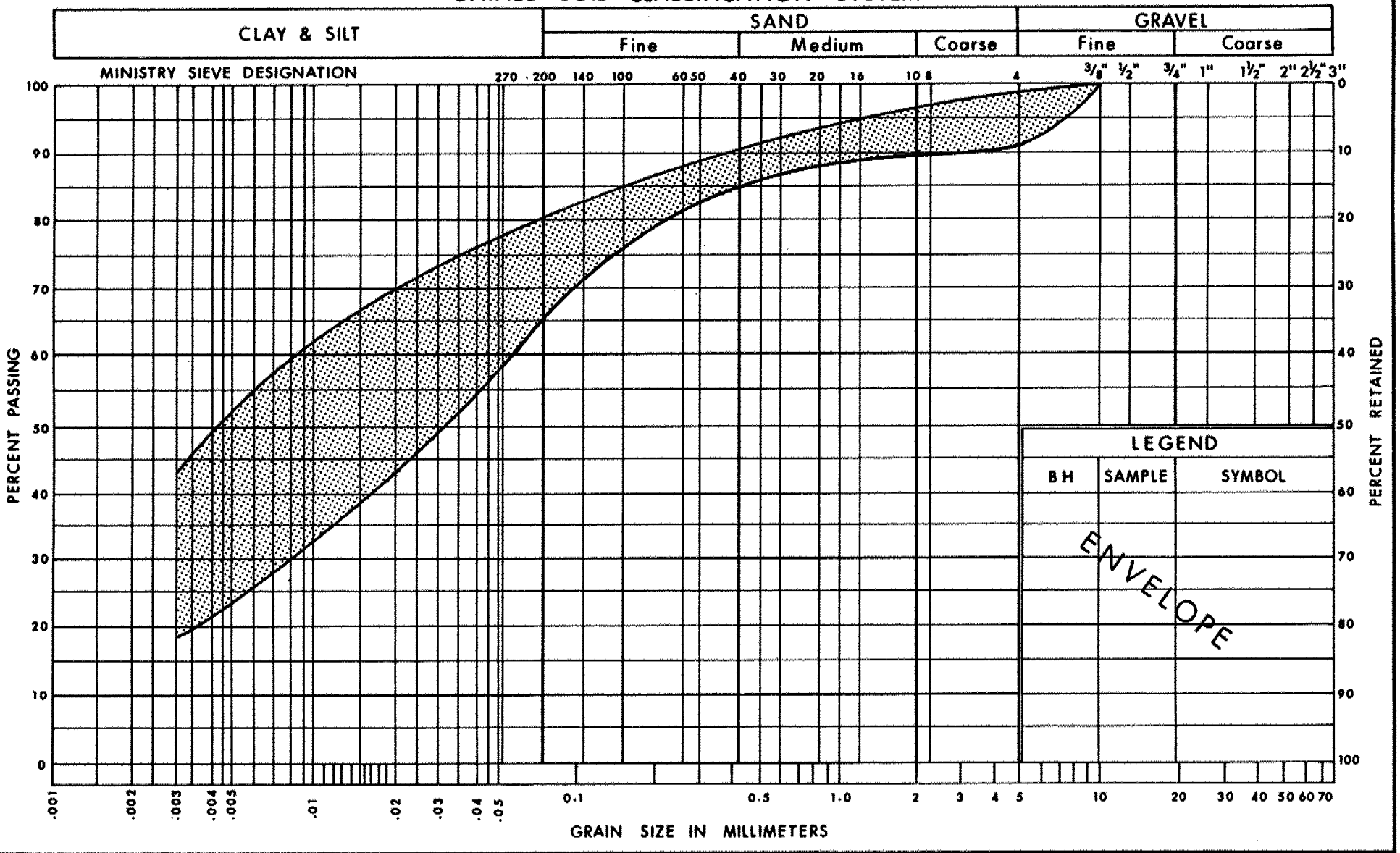
PLASTICITY CHART
CLAYEY SILT
SOME SAND, TRACE OF GRAVEL

FIG No 1
W P 258-66-03

UNIFIED SOIL CLASSIFICATION SYSTEM



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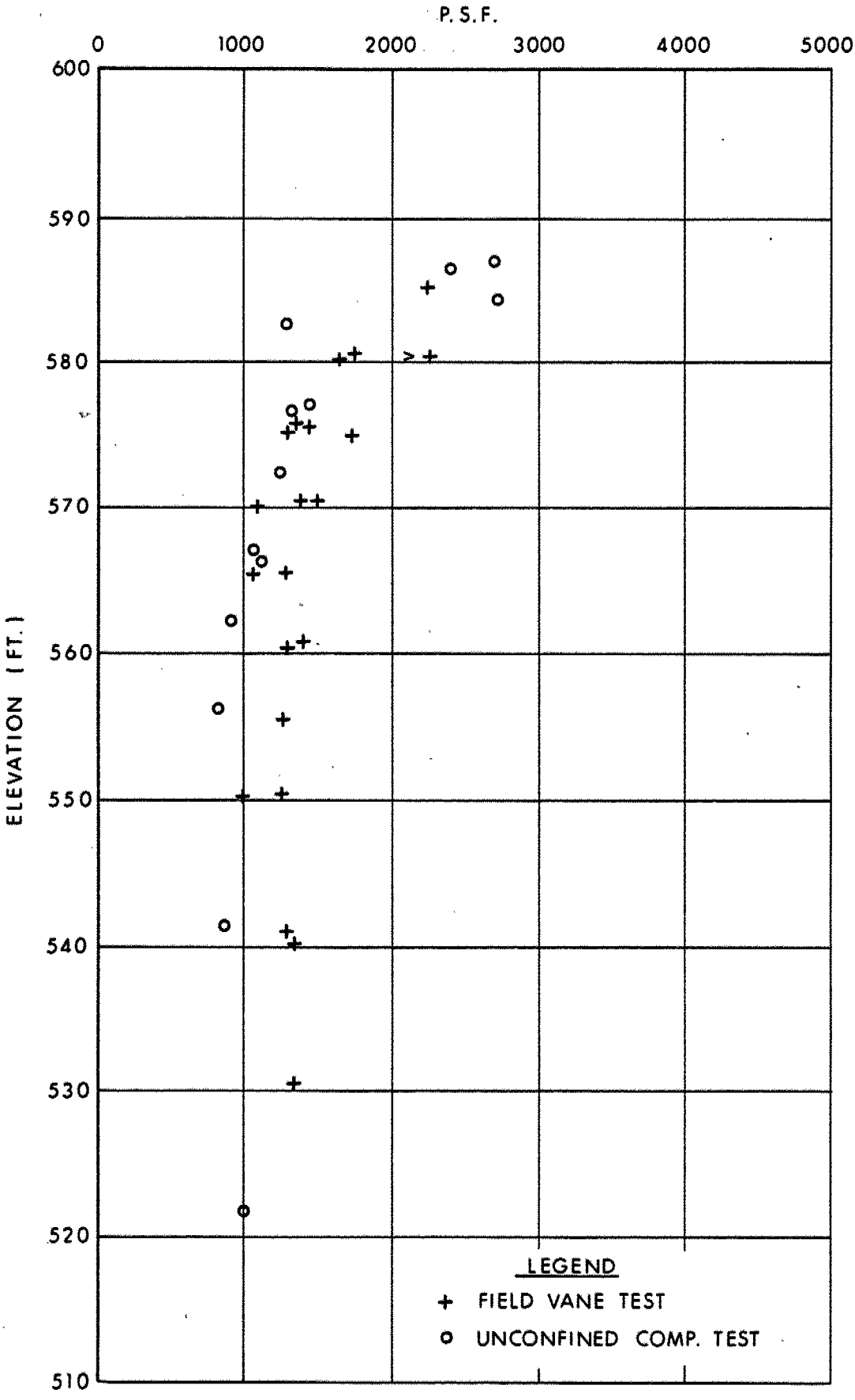
GRAIN SIZE DISTRIBUTION
CLAYEY SILT
SOME SAND, TRACE OF GRAVEL

FIG No 2

W P 258-66-03



SHEAR STRENGTH Vs ELEVATION

FIG. 3

W.P. 258-66-03

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 $\bar{N}$.

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. $\overline{CIU}$ = 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_γ, 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 = $\frac{w - w_p}{I_p}$
I_c	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
A_c	ACTIVITY = $\frac{I_p \text{ of soil}}{\%\text{- } 2\mu m \text{ Soil Fraction}}$
Om	ORGANIC MATTER CONTENT
S_r	DEGREE OF SATURATION
S	SENSITIVITY = $\frac{S_u \text{ (undisturbed)}}{S_u \text{ (remoulded)}}$

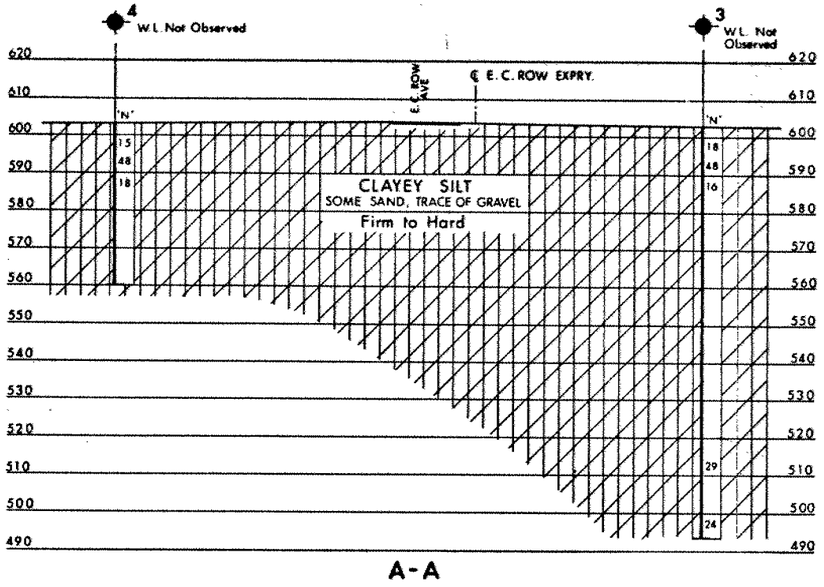
STRENGTH PARAMETERS

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
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

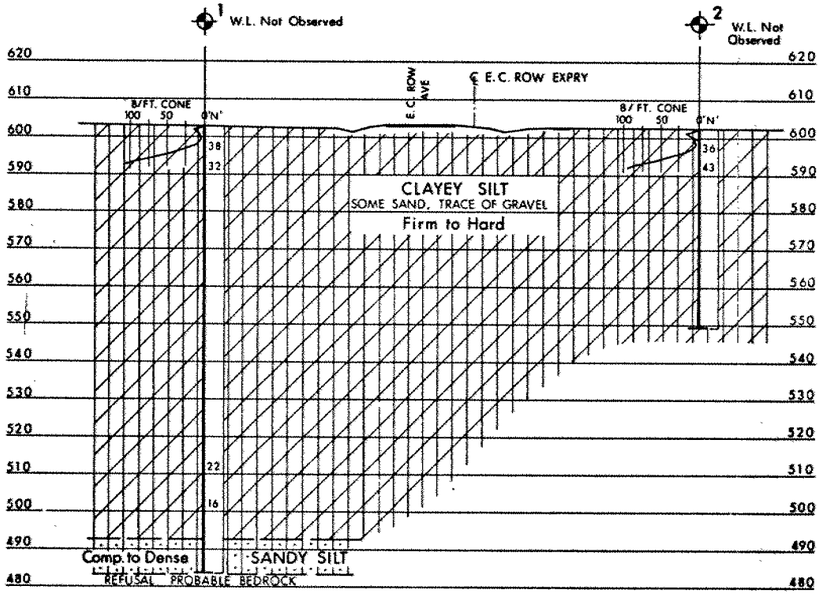
NOTE: EFFECTIVE STRESS PARAMETERS ARE DENOTED BY USE OF APOSTROPHE ABOVE THE SYMBOL, THUS:
ϕ' = EFFECTIVE ANGLE OF SHEARING RESISTANCE;
σ' = EFFECTIVE NORMAL STRESS

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
OCR	OVERCONSOLIDATION RATIO (OCR)



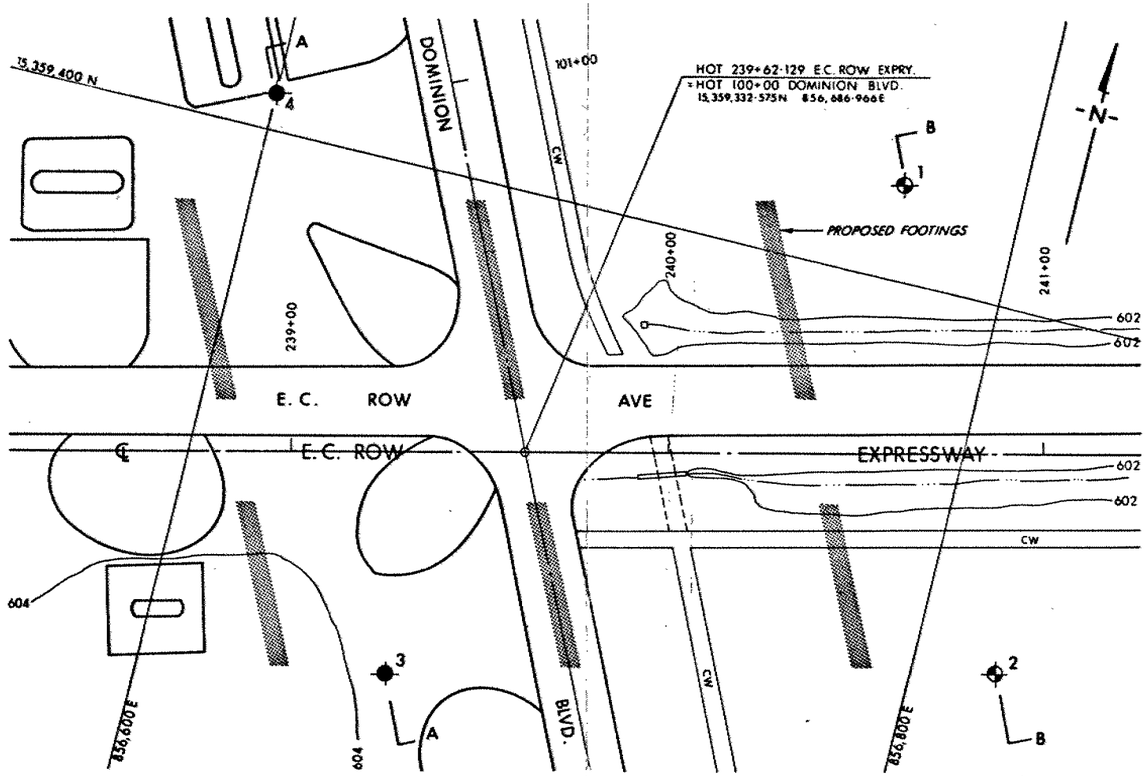
A-A



B-B

SECTIONS

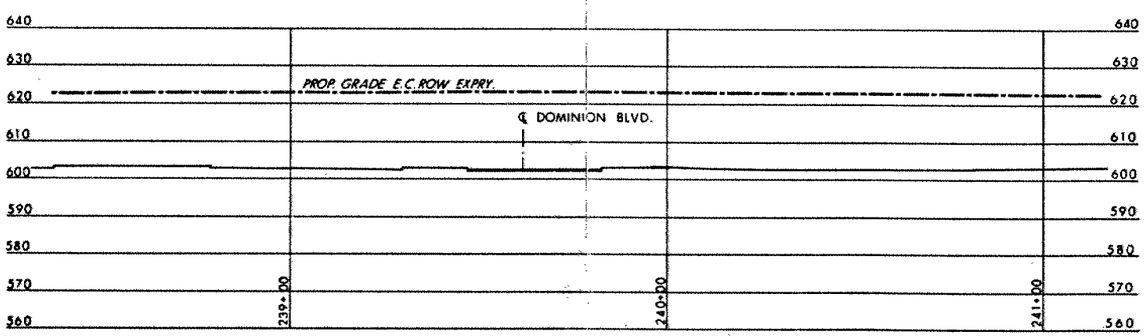
20 10 0 SCALE 20 40 FT.



PLAN

20 10 0 SCALE 20 40 FT

NOTE: GROUND CONDITIONS AS OF TIME OF FIELD INVEST. MARCH, 1968.



℄ PROFILE - E.C. ROW EXPRY.

20 10 0 SCALE 20 40 FT.

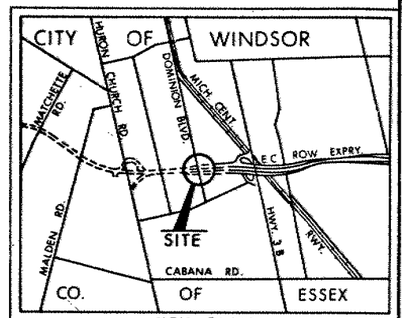
REF. NO. E-5329-1 MAR 1972

CONT No
WP No 258-66-03

DOMINION BLVD. OVERPASS

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)
- W.L. at time of investigation
- W.L. Not Observed

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	602·5	15,359,425	856,768
2	602·6	15,359,305	856,822
3	603·0	15,359,267	856,665
4	603·0	15,359,409	856,600

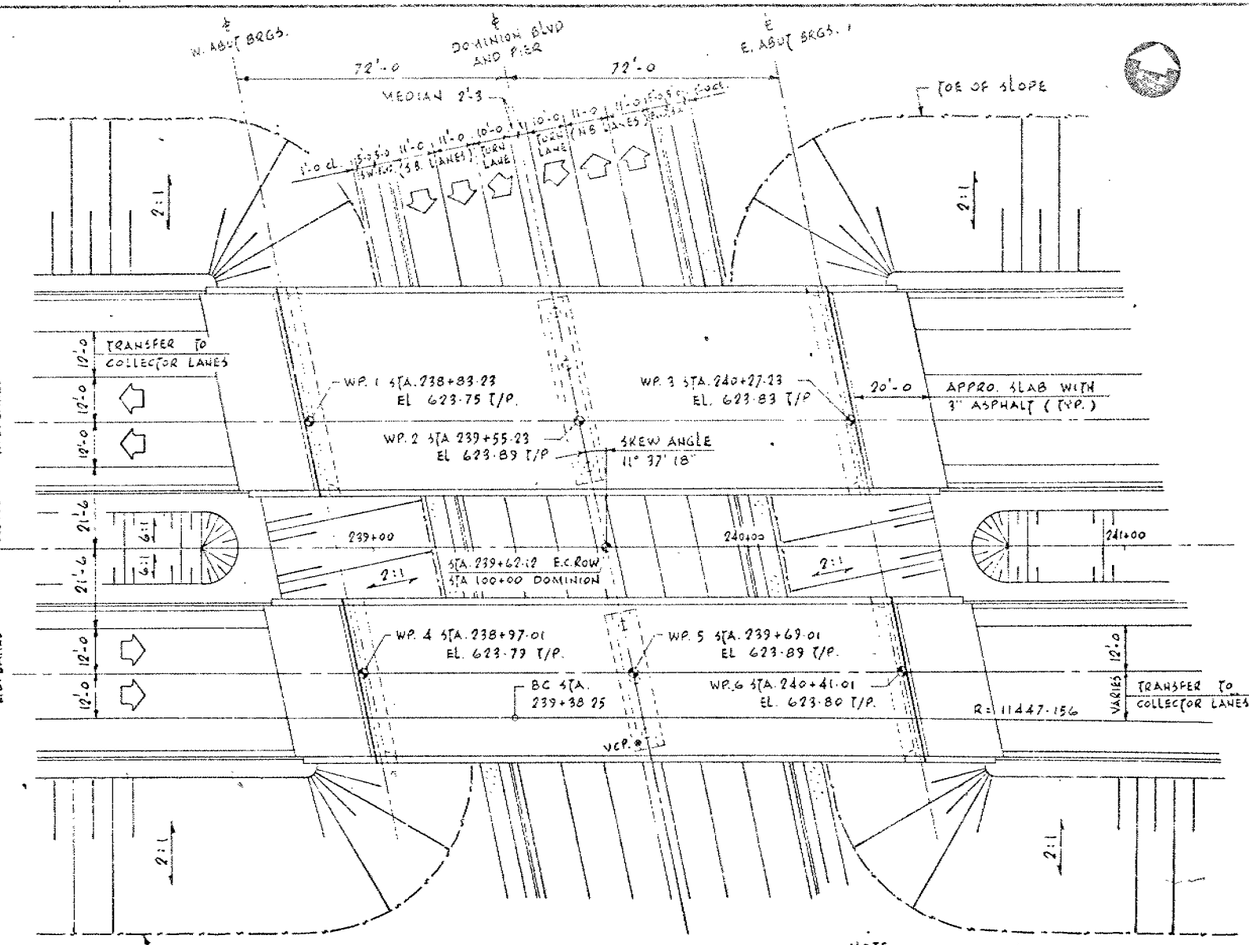
-NOTE-
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

REVISIONS

DATE	BY	DESCRIPTION

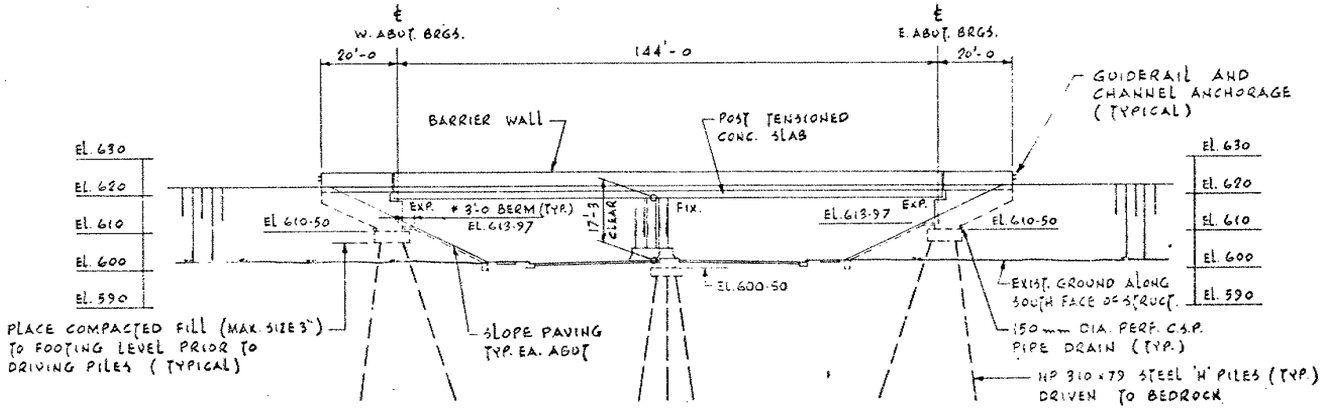
Geocres No 40J6-13

HWY No E.C. ROW EXPRY.			DIST 1
SUBM'D PP	CHECKED	DATE 1 Sept. 82	SITE 6-1398-284
DRAWN S.O.	CHECKED	APPROVED	DWG 2586603-A



PLAN
1" = 20'-0"

NOTE
W.P. DENOTES WORKING POINT
T/P DENOTES TOP OF PAVEMENT
VCP. DENOTES VERTICAL CLEARANCE POINT (MIN.)

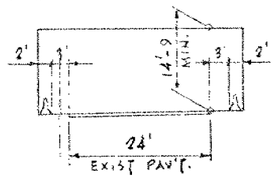


ELEVATION
1" = 20'-0"

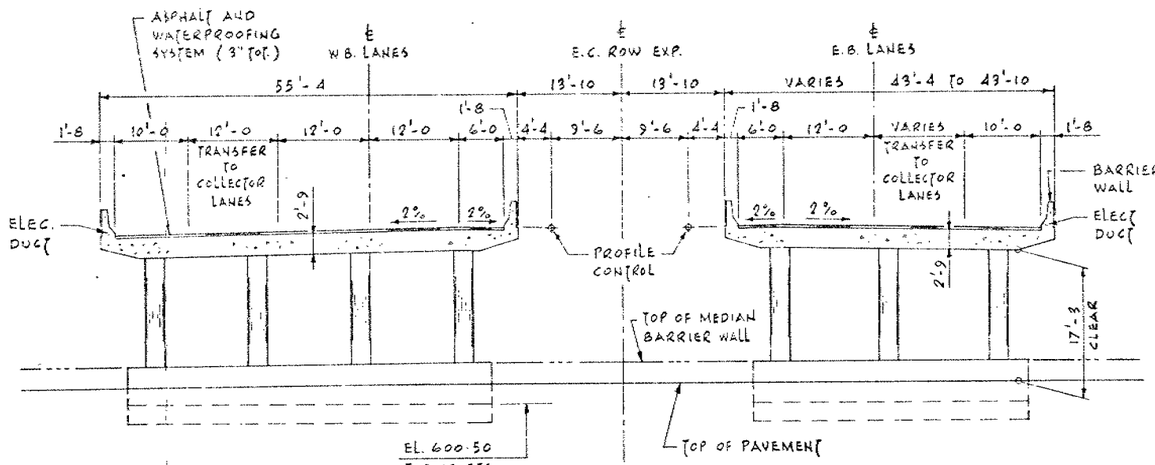
* MEASURED PERPENDICULAR TO ℄ DOMINION BLVD.

MTC PRECISE B.M. # 524-66
ELEVATION 182.724 M.
599.461 Ft.

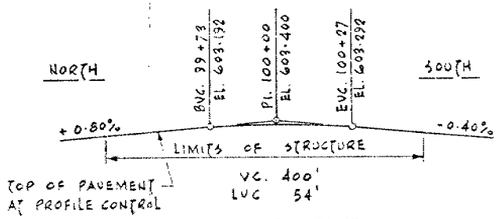
ALL HORIZ. DIMENSIONS SHOWN ARE REQUIRED MINIMUM



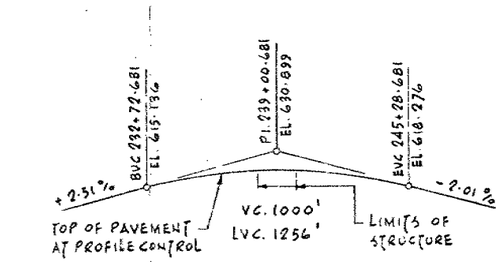
FALSEWORK CLEARANCES
TYPICAL N.B. & S.B. LANES



SECTION
1" = 10'-0



DOMINION BLVD.



E.C. ROW EXPRESSWAY

PROFILE DATA
N.T.S.

LIST OF DRAWINGS

GENERAL NOTES

CLASS OF CONCRETE

PIERS, DECK	35 MPa
BARRIER WALLS, ABUTMENTS	30 MPa
REMAINDER	20 MPa

CLEAR COVER TO REINFORCING STEEL

FOOTINGS		4" ± 1"
PIERS		3" ± 3/4"
ABUTMENTS	FRONT FACE (F.F.)	3" ± 3/4"
	BACK FACE (B.F.)	2¾" ± 3/4"
DECK	TOP BARS	2¾" ± 3/4"
	BOT. BARS	2" ± 3/8"

REMAINDER 2¾" ± 3/4" UNLESS SHOWN OTHERWISE.

GRADE OF REINFORCING STEEL

REINFORCING STEEL SHALL BE GRADE 400 REINFORCING BARS MARKED WITH THE SUFFIX "C" SHALL BE EPOXY COATED.

CONSTRUCTION NOTES

THE CONTRACTOR IS RESPONSIBLE FOR FINISHING THE BEARING SEATS DEAD LEVEL TO THE SPECIFIED ELEVATIONS WITH A TOLERANCE OF ± 1/8"

NO CONCRETE SHALL BE PLACED ABOVE THE ABUTMENT BEARING SEATS UNTIL THE CONCRETE IN THE DECK HAS BEEN PLACED, STRESSED AND GROUTED.

DISTRICT No. 1
CONT No
WP No 258-66-03

E.C. ROW EXPRESSWAY E.B.L. DOMINION BLVD. OVERPASS

GENERAL ARRANGEMENT

SHEET

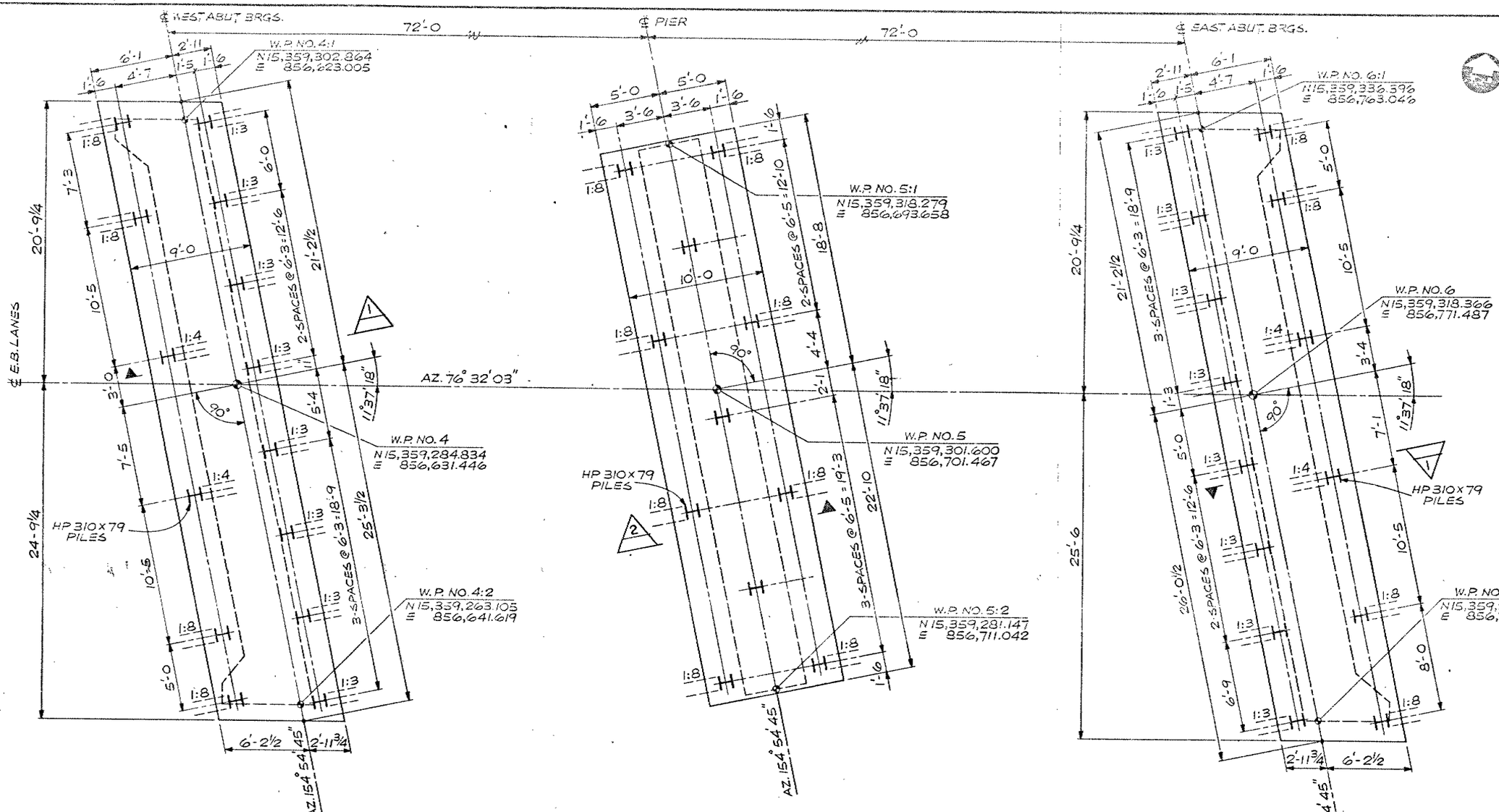
DILLON
Consulting Engineers & Planners

M. A. DE PAUW
REGISTERED PROFESSIONAL ENGINEER
PROVINCE OF ONTARIO

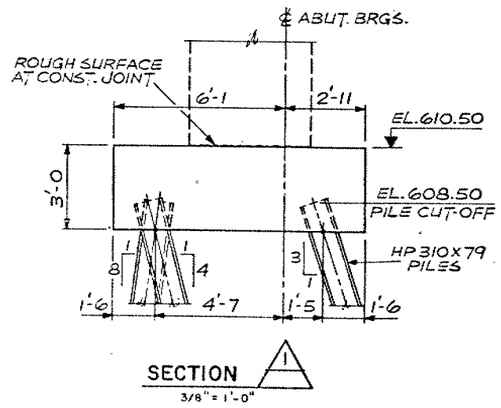
G. KNIGHTS
REGISTERED PROFESSIONAL ENGINEER
PROVINCE OF ONTARIO

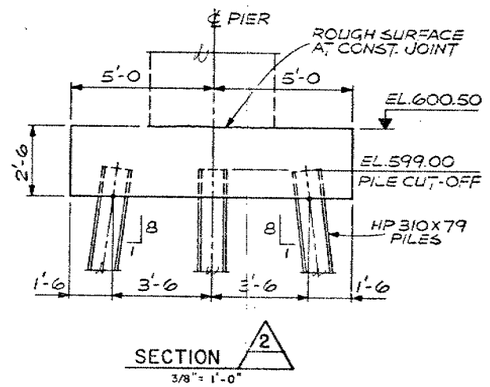
FOR REDUCED PLANS
USE SCALE BELOW
0 1 2 3
3 INCHES ON ORIGINAL PLAN

REVISIONS			
DATE	BY	DESCRIPTION	
DESIGN M.D.P.	CHECK G.K.	LOADING CHBDC-A-79	DATE MAY 83
DRAWING L.T.	CHECK G.K.	SITE No 6-1396-284A	DWG 1



PLAN
1/4" = 1'-0"





DISTRICT No. 1
CONT No
WP No 258-66-03

E C ROW EXPRESSWAY E.B.L.
DOMINION BLVD. OVERPASS

FOUNDATION LAYOUT

SHEET

DILLON
Consulting Engineers & Planners

NOTES
- ALL PILES ARE HP 310x79
- PILE SPACING TO BE MEASURED AT UNDERSIDE OF FOOTING
- DESIGN LOAD AT S.L.S. II = 130 TONS FACTORED CAPACITY AT U.L.S. = 180 TONS
- PILE LENGTH SHOWN ON DRAWING IS THEORETICAL LENGTH BELOW CUT-OFF.
- LEGEND
  H = VERTICAL PILE
  H = DIRECTION OF PILE BATTER
  1:3, 1:4, & 1:8 = RATE OF BATTER
- PROVIDE DRIVING SHOES FOR ALL PILES AS PER STD. SS 3-1
- PILES TO BE DRIVEN TO BEDROCK

PILE DATA TABLE

LOCATION	ROW	BATTER	NO.	LENGTH
WEST ABUTMENT	FRONT	1:3	8	135'
	REAR	1:4	2	132'
		1:8	4	129'
PIER	EXT.	1:8	8	120'
	CENT.	VERT.	3	120'
EAST ABUTMENT	FRONT	1:3	8	135'
	REAR	1:4	2	132'
		1:8	4	129'

REGISTERED PROFESSIONAL ENGINEER M. A. DE PAUW PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER G. KNIGHTS PROVINCE OF ONTARIO

DRAWING NOT TO BE SCALED
0 1 2 3
3 INCHES ON ORIGINAL PLAN

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN MDeP	CHECK GK	LOADING OHBDC-CL-79	DATE MAY 83
DRAWING GLB	CHECK JB	SITE No 6-13382-2814	DWG 3

memorandum

Ontario

To: J.L. Keen
Design Engineer
Structural Office
4th Floor, 3501 Dufferin St.

Date: 83 08 23

From: Pavement and Foundation
Design Section
Room 315, Central Building

Re: Final Design Review
Dominion Blvd. Overpass
E.B.L. and W.B.L. Bridges
W.P. 258-66-03, Site 6-1398-284
E.C. Row Expressway, District 1

The submitted final drawings and provisions have been reviewed by this Section.

There are no comments.

K.G. Selby, P. Eng.
Senior Foundations Engineer

KCS/DD/mmj

memorandum

Ontario

To: Mr. J.L. Keen
Design Engineer (Southwestern)
Structural Office
3501 Dufferin St., 4th Floor

Date: 83 01 25

From: Pavement & Foundation Design Section
Room 315, Central Bldg.
Downsview

Re: E.C. Row Expressway
Highway 3 Overpass - W.P. 258-66-02
Dominion Blvd. Overpass - W.P. 258-66-03
District #1 (Chatham)

This will confirm recommendations given to you by telephone by the writer on 83 01 25 regarding the piled foundations for the above-mentioned structures. Based on the results of recent pile testing, carried out at the site of the New Burlington Skyway, we are of the opinion that the design geotechnical capacity of 12 BP @ 53 Steel H piles fitted with reinforced tips and driven to bedrock at the Highway 3 and Dominion Blvd., structure sites, W.P. 258-66-02/03, may be as high as 130 tons per pile. The minimum quality of the steel should be Grade 44W manufactured in accordance with CSA G40.21. For purposes of the O.H.B.D.C. the following is applicable for these piles:-

Factored Capacity at U.L.S. = 180 tons
Capacity at S.L.S. Type II = 130 tons

At no time should the axial loads on the piles exceed the recommended design capacity of 130 tons.

It should be noted that all capacities quoted above are geotechnical capacities and therefore the structural designer must ensure that the 12 BP @ 53 section is structurally adequate for the purpose intended and complies with the requirements of the O.H.B.D.C.

The foregoing supersedes recommendations relating to piles in the foundation reports for the two structures in question, W.P.s 258-66-02/03.

K.G. Selby, P. Eng.
Senior Foundations Engineer

KGS:syc

cc: K. Bassi
V. Boehnke

memorandum

Ontario

To: Mr. V.F. Boehnke
Head, Structural Section
Southwestern Region

Date: 82 07 30

Att'n: Mr. A.P. Watt

From: Pavement & Foundation Design
Room 315, Central Building
Downsview, Ontario

Re: Dominion Blvd. Interchange - Overpass
E.C. Row Expressway
W.P. 258-66-03; Site No. 6-1398-284

A foundation investigation was carried out at the above-mentioned site. In order that you might proceed with the design of the proposed overpass structure, we are submitting our findings and recommendations prior to completion of the final report.

SUBSURFACE CONDITIONS

The subsoil at the site consists of an about 110 ft. thick clayey silt, some sand and traces of gravel, followed by a 9 ft. deep sandy silt, with some gravel. Limestone type bedrock may be assumed to be at elevation 483.5 ±. The groundwater level is estimated to be some 2 - 3 feet below the ground surface.

STRUCTURE FOUNDATIONS

Piled 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 119 feet below ground level. These piles could be either steel 'H' piles or concrete filled steel tube piles. 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 piles when contact with bedrock is made.

For the purposes of the O.H.B.D.C. the following design values are recommended:

	12 BP @ 74	12 BP @ 53
Factored Capacity at U.L.S.	180 tons	95 tons
Capacity at S.L.S. Type II	130 tons	70 tons

Steel Tube Piles (12 3/4" X 1/4")

Factored Capacity at U.L.S.	180 tons
Capacity at S.L.S. Type II	130 tons

Earth pressures should be computed as per subsection 6.6.1.2.2 of the code. For the granular backfill (non-yielding foundation) a value of $K_o = 0.5$ is recommended.

Spread Footings

The entire structure may be supported on spread footings placed within the original subsoil between elevation 591 and elevation 595. The following design values are recommended:

Factored Bearing Capacity at U.L.S.	3.25 TSF
Bearing Capacity at S.L.S. Type II	2.50 TSF

Earth pressures should be computed as per subsection 6.6.1.2.2 of the O.H.B.D.C. assuming a yielding foundation condition with $K_A = 0.33$ for granular backfill.

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. It is recommended that this portion of the fill contain no larger grain size than 2 inches if steel tube piles are considered or larger than 3 inches in the case of steel 'H' piles.

Settlement Considerations

Due to the compressible nature of the predominant subsoil (clayey silt), it is inevitable that consolidation settlements will occur over a longterm period due to the imposed loads of structure abutments on spread footings and embankments. 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. Based on the experiences with similar structures under similar subsoil conditions, it can be concluded that 50% of the total settlement will be completed in about 6 months' time.

For piers, it is estimated that settlements of spread footings will be in the order of 1½ to 2 inches. Thus, differential settlements up to 3½ inches between the piers and abutments if supported on spread footings are anticipated. Regardless of whether the structure is wholly or partly on spread footings,

it would be advantageous to construct the embankments well in advance of the structures in order to minimize future differential settlements. Consideration should also be given to surcharging at the abutments' location if spread footing type support is used. The aforementioned granular core should be placed first and earth fill could be placed up to the grade of surcharge level.

Other Considerations

The pile caps and/or the underside of the spread footings should be protected against frost penetration with a minimum cover of 4 feet.

The topsoil stripping should be in accordance with current MTC standards.

No major dewatering problems are anticipated.

Should the piles be driven closer than 12 feet from underground utilities, preboring to a minimum depth of 6 feet below such utilities is recommended.

Our complete foundation investigation report will be forwarded to you in the near future after the necessary drafting work is finished.

for P. Payer, P. Eng.
Foundations Engineer

PP/jb

W.P. 258-66-03 Dominion Blvd. Overpass E. C. Row Expwy. Site 6-284

Looking west along E. C. Row at Dominion Blvd.

- OLD PICTURE
- E.C ROW EXPRESSWAY HAS BEEN GRADED & RECONSTRUCTED.

#67-F-250M

HOWES BRIDGE

LOT 21, CONS. X/X1

HIBBERT TWP.

R. M. DAWSON P.ENG.
CONSULTING ENGINEER
258 WILLIAM STREET
STRATFORD ONTARIO

67-F-250M

Report on

SOIL INVESTIGATION

for

HOWES BRIDGE

LOT 21, CONCESSIONS X & XI

TOWNSHIP OF HIBBERT.

by

DOMINION SOIL INVESTIGATION LIMITED
369 Queens Avenue
LONDON ONTARIO

Reference No. 7-3-L6
March 23rd, 1967

CONTENTS

ENCLOSURES

SUMMARY

The two boreholes revealed a natural soil profile consisting of a thin layer of silty fine sand (4'-6" thick) overlying hard silty clay strata in which borehole 1 was terminated at El. 70. Borehole 2 encountered a stratum of very dense silty sandy gravel at El. 82 and was terminated in this stratum at El. 70.

It is recommended that the structure be supported on spread footing foundations within the silty clay stratum at or below El. 91, using a maximum net soil pressure of 8000 p.s.f. Total settlement is estimated to be less than 1-inch.

Excavations through the silty fine sand stratum below the water table will require lateral support to prevent a flow of soil and water into the excavation.

I INTRODUCTION

In accordance with a letter of authorization, dated March 9, 1967, from Mr. R. M. Dawson, P. Eng., Consulting Engineer, a soil investigation has been carried out in the Township of Hibbert where it is proposed to replace an existing road bridge with a new structure.

The existing structure is located on Lot 21, Concessions 10 and 11 of the Township and is named Howes Bridge.

It is understood that the proposed structure is a 40 foot span concrete rigid frame with a skew of 45 degrees. Also the transverse centre line will be moved 125 feet to the west of the centre line of the existing structure.

The purpose of this investigation was to reveal the subsurface conditions at the site and to determine the relevant soil properties for the design and construction of the new foundations.

II DESCRIPTION OF THE SITE AND GEOLOGY

The site is located about 2 miles west of Cromarty in the western corner of Perth County.

The physiographic region, known as the Stratford Till Plain, is an area of ground moraine interrupted by several terminal moraines. The overall slope is to the southwest and this particular site lies within the Ausable River watershed. Throughout the area the till is fairly uniform, being a brown calcareous silty clay

whether on the ridges or the more level ground moraine. The silt and clay contents vary within certain limits and so does the stoniness, but it is seldom a stony till.

III FIELD WORK

The field work, consisting of two boreholes, was carried out during the period March 15 to 17, 1967, at the locations shown on Enclosure 2. The boreholes were advanced to the sampling depths by washboring methods and were lined with Bx size casing.

Standard penetration tests were carried out at frequent intervals of depth, as detailed on Appendix 'A', and the results are recorded on the Geotechnical Data Sheets as 'N' values.

Dynamic cone penetration tests were performed adjacent to each borehole location to obtain an indication of soil density changes with depth. The same source of energy was used to drive the cone as was used for the standard penetration test.

Elevations were referred to a benchmark which was indicated on the client's site plan (Deck elevation of existing bridge El. 101.9 feet).

IV SUBSURFACE CONDITIONS

Detailed descriptions of the strata encountered in each borehole are given on the Geotechnical Data Sheets, comprising Enclosures 3 and 4, and a general picture of the soil stratigraphy is given in the form of a Subsurface Profile on Enclosure 2.

The boreholes revealed the following general ground succession:-

		Thickness	
		Borehole 1	Borehole 2
(a)	Brown silty clay with a little gravel (Fill)	4'- 6"	4'- 6"
(b)	Grey organic silt	1'- 0"	Nil
(c)	Brown silty fine sand containing seams of silty clay. The relative density of this stratum is described as 'compact' to 'dense' as estimated from 'N' values ranging from 27 to 32 blows per foot.	4'- 0"	2'- 6"
(d)	Grey silty clay containing seams of sandy silt. The consistency of this stratum is described as 'hard' as indicated by 'N' values ranging from 34 to 55 blows per foot.	3'- 6"	5'- 6"
(e)	Grey silty clay containing traces of sand and gravel (Glacial Till). The consistency of this stratum is described as 'hard' as indicated by 'N' values ranging from 25 to 185 blows per foot.	Penetrated 18'- 3"	6'- 6"
(f)	Grey silty sandy gravel. The relative density of this stratum is described as 'very dense' as estimated from 'N' values of 100 blows for less than 1 foot penetration of the sampler.	Nil	Penetrated 11'- 3"

V GROUNDWATER CONDITIONS

The average water level observed in the boreholes after completion of the field work was El. 98.2, which was the same elevation as the water level in the adjacent creek.

VI LABORATORY TESTS

Atterberg Limit and moisture content tests were carried out on 2 samples of the silty clay stratum as a means of classification and as a guide to the probable behaviour of the soil. These gave values of Liquid Limit of 15% and 25%; Plastic Limit of 9% and 13% and Plasticity Index of 6 and 12 indicating that the soil is a clay of low plasticity and compressibility. The Liquidity Indices which relate the natural moisture content of the clay to the Atterberg Limits were 0.2 indicating a 'very stiff' consistency.

The results of the Atterberg Limit and moisture content tests are plotted graphically on the Geotechnical Data Sheet for each borehole.

VII DISCUSSION AND RECOMMENDATIONS

The natural soil profile consists of a thin layer of compact to dense silty fine sand, overlying hard silty clay strata. A lens of very dense silty sandy gravel was encountered below the silty clay at borehole 2 location.

Two factors govern the choice of footing grade. First, there should be a minimum of 4 feet depth of soil cover for protection against frost action, and second the footings should have sufficient protection against scour erosion. The fine sand stratum is considered highly susceptible to erosion, therefore on this basis, it is recommended that the footings should bear at or below El. 91.

The final footing grade will be determined by carrying out a hydrological study to determine the maximum depth of scour, which is beyond the limits of this report.

Bearing Capacity

On the basis of the borehole results, footings bearing in the silty clay stratum at or below El. 91 may be designed using a maximum net soil pressure of 8000 p.s.f. This bearing value incorporates a factor of safety of 3 against shear failure of the underlying soil.

The adhesion between the footings and the silty clay may be taken as 2000 p.s.f. and the factor of safety against horizontal sliding of the abutments should be at least 1.5.

Settlement

It is estimated that total settlement will not exceed 1-inch and in view of the similar conditions encountered in the two boreholes, no appreciable differential settlement is anticipated.

Construction

The hard silty clay strata will present no unusual construction problems. However excavations through the silty fine sand will require lateral support to prevent a flow of soil and water into the excavation.

It is anticipated that seepage into excavations will be collected in sumps dug below the footing grade and removed by pumping.

Yours very truly,

DOMINION SOIL INVESTIGATION LIMITED

C.J.W. Atkinson, M.Sc., P.Eng.,
Branch Manager

CJWA:jms

APPENDIX A

STANDARD PENETRATION TESTS

In order to determine the relative density of non-cohesive soils, such as sands and gravels, the standard penetration test has been adopted. The test also gives an indication of the consistency of cohesive soils.

A two-inch external diameter thick-walled sample tube is driven into the ground at the bottom of the borehole by means of a 140 lb. hammer falling freely through 30 in. The tube is first driven an initial 6 in. to allow for the presence of disturbed material at the bottom of the borehole. The number of standard blows (N) required to drive the sampler a further 12 in. is recorded. The sample tube used is one originally developed by the Raymond Concrete Pile Company in the United States, where a sufficient number of tests have been made in conjunction with field investigations to show that the results, although essentially empirical, may be applied to foundation design.

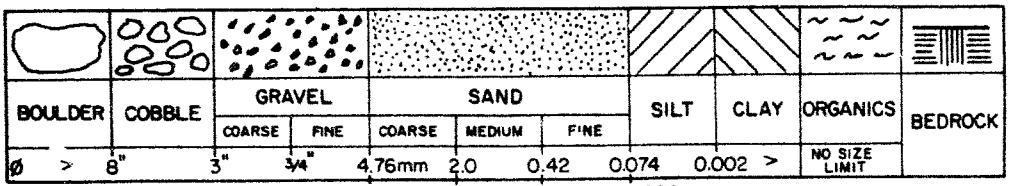
For sands:

Values of N	Density
Less than 10	Loose
Between 10 and 30	Compact
Between 30 and 50	Dense
Greater than 50	Very dense

Enclosures

LIST OF SYMBOLS, ABBREVIATIONS AND NOMENCLATURE.

SOIL COMPONENTS AND GROUND WATER CONDITIONS.



SAMPLE TYPES.

AS	Auger sample	RC	Rock core	TP	Piston, thin walled tube sample
CS	Sample from casing	%	Recovery	TW	Open, thin walled tube sample
ChS	Chunk sample	SS	Split spoon sample	WS	Wash sample

SAMPLER ADVANCED BY static weight : w
" pressure : p
" tapping : t

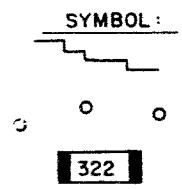
OBSERVATIONS MADE WHILE CORING: Steady pressure; No pressure; Intermittent pressure; Washwater returns; Washwater lost

PENETRATION RESISTANCES.

DYNAMIC PENETRATION RESISTANCE : to drive a 2"ϕ, 60° cone attached to the end of the drilling rods into the ground, expressed in blows per foot.

STANDARD PENETRATION RESISTANCE, -N- : to drive a 2" outside dia, split spoon sampler 1 foot into the ground, expressed in blows per foot.

SYMBOL :



EXTRAPOLATED -N- VALUE

The energy for the penetration resistances is supplied by a 140 lb. hammer falling 30 inches

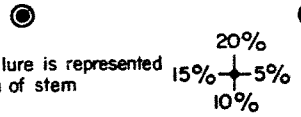
SOIL PROPERTIES.

W %	Water content	γ	Natural bulk density (unit weight)	k	Coeff. of permeability
LL %	Liquid limit	e	Void ratio	C	Shear strength — in terms of total stress
PL %	Plastic limit	RD	Relative density	ϕ	Angle of int. friction — in terms of total stress
PI %	Plasticity index	C_v	Coeff. of consolidation	C'	Cohesion — in terms of effective stress
LI	Liquidity index	m_v	Coeff. of volume compressibility	ϕ'	Angle of int. friction — in terms of effective stress

UNDRAINED SHEAR STRENGTH.

— DERIVED FROM —

TRIAXIAL COMPRESSION TEST — UNCONFINED TEST — LABORATORY VANE TEST — FIELD VANE TEST — POCKET PENETROMETER TEST



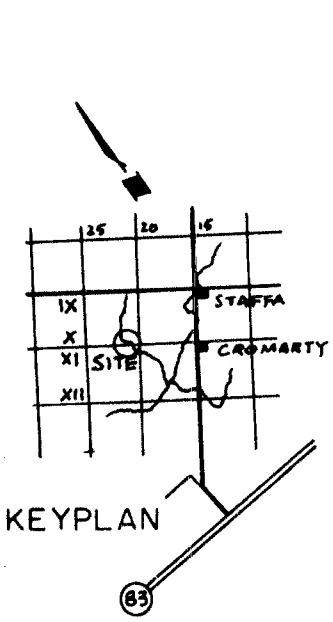
Strain at failure is represented by direction of stem

St : sensitivity = $\frac{\text{shear strength in undisturbed state}}{\text{shear strength in remoulded state}}$

SOIL DESCRIPTION.

COHESIONLESS SOILS :	RD :	COHESIVE SOILS :	C lbs/sq.ft.
Very loose	0 – 15 %	Very soft	less than 250
Loose	15 – 35 %	Soft	250 – 500
Compact	35 – 65 %	Firm	500 – 1000
Dense	65 – 85 %	Stiff	1000 – 2000
Very dense	85 – 100 %	Very stiff	2000 – 4000
		Hard	over 4000

DOMINION SOIL INVESTIGATION LIMITED



KEYPLAN

TWP. OF HIBBERT

50'

100'

B.M. TOP OF EXISTING BRIDGE DECK EL. 101.9'

BH.1

6'

10'

BH.2

℄ OF EXISTING ROAD

FLOW

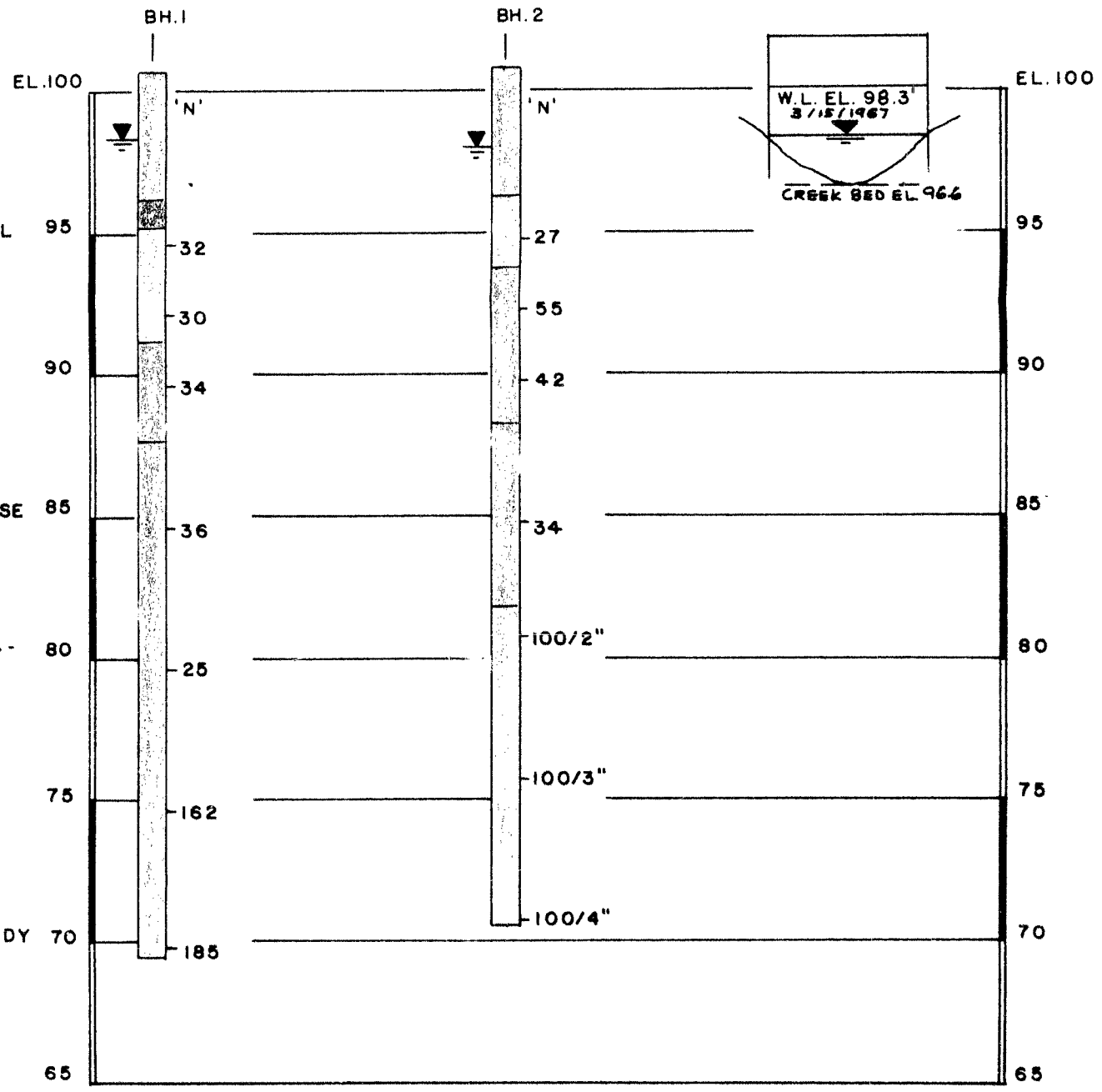
℄ OF EXISTING BRIDGE

LOCATION OF BOREHOLES

SCALE 1" - 20'

LEGEND

- SILTY CLAY FILL
- ORGANIC SILT
- COMPACT TO DENSE SILTY FINE SAND
- HARD SILTY CLAY
- HARD SILTY CLAY TILL
- VERY DENSE SANDY SILTY GRAVEL



SUBSURFACE PROFILE

VERT. SCALE 1"- 5'

OUR REF. No. 7 - 3 - L6

DOMINION SOIL INVESTIGATION LIMITED

ENCLOSURE No. 2

GEOTECHNICAL DATA SHEET FOR BOREHOLE 1

OUR REFERENCE NO 7-3-L6

CLIENT R.W. Dawson, Consulting Engineer, METHOD OF BORING Washboring ENCLOSURE NO 3
PROJECT Proposed Bridge DIAMETER OF BOREHOLE Bx (3-inch)
LOCATION Lot 21, Conc. 10 & 11, Twp. of Hibbert DATE March 15 & 16, 1967
DATUM ELEVATION 101.9 feet. Top of existing bridge deck.

ELEVATION ft	DEPTH ft	STRATIFICATION DESCRIPTION	STRATIFICATION SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES N or Advancement of Sampler	PENETRATION RESISTANCE blows per foot 20 40 60 80 100 / SHEAR STRENGTH lbs sq ft	CONSISTENCY water content % Pl W Ll 10 20 30 40	REMARKS
100.7	0.0	Ground Surface							
		Brown silty clay, little gravel. (Fill)							
	4.5	Grey organic silt							
95	5.5	Dense brown silty fine sand and seams of clay		1	SS	32			
				2	SS	30			
	9.5	Hard grey silty clay, seams of sandy silt		3	SS	34			
90	13.0	Hard grey silty clay traces of sand and gravel (Glacial Till)		4	SS	36			
85				5	SS	25			
80				6	SS	162			
75				7	SS	185			
70	31.3	End of Borehole							

2" diameter cone

W. L. El. 98.4

VERTICAL SCALE, 1 IN TO FT

DOMINION SOIL INVESTIGATION LIMITED

MADE CH'D

GEOTECHNICAL DATA SHEET FOR BOREHOLE . 2 . . . .

OUR REFERENCE NO 7-3-L6

CLIENT R.W. Dawson, Consulting Engineer, METHOD OF BORING Washboring ENCLOSURE NO 4
PROJECT Proposed Bridge DIAMETER OF BOREHOLE Bx (3-inch)
LOCATION Lot 21, Conc. 10 & 11, Twp. of Hibbert DATE March 16 & 17, 1967
DATUM ELEVATION 101.9 feet, Top of existing bridge deck.

ELEVATION ft	DEPTH ft	STRATIFICATION DESCRIPTION	STRATIFICATION SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES No. of Advancement of Sampler	PENETRATION RESISTANCE blows per foot 20 40 60 80 100 / SHEAR STRENGTH lbs/sq ft	CONSISTENCY water content % PL W LL 10 20 30 40	REMARKS
100.8	0.0	Ground Surface							
		Brown silty clay, little gravel (Fill)							
	4.5	Compact brown silty fine sand seams of clay		1	SS	27			
95	7.0	Hard silty clay, seams of sandy silt.		2	SS	55			
90	12.5			3	SS	42			
		Hard grey silty clay, traces of sand and gravel (Glacial Till)		4	SS	34			
85	19.0								
		Very dense grey silty sandy gravel		5	SS	100/2"			
80									
				6	SS	100/3"			
75									
				7	SS	100/4"			
70	30.3	End of Borehole							

2" diameter cond

W. L. El.98.0

VERTICAL SCALE: 1 IN TO 5 FT

DOMINION SOIL INVESTIGATION LIMITED

MADE CH'D