

GEOCRES No. 30M15-43, 44, 46, 52

DIST. 6 REGION

W.P. No. 38-77-01

CONT. No. 82-72

W. O. No. \_\_\_\_\_

STR. SITE No. \_\_\_\_\_

HWY. No. 401

LOCATION Thickoon Rd .  
(South Service Rd)

No of PAGES - 1

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. \_\_\_\_\_

REMARKS: \_\_\_\_\_

.....

.....

site 8

# FOUNDATION INVESTIGATION REPORT

CONTRACT NO 82 - 72



Ministry of  
Transportation and  
Communications

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	W.P. 38-77-02      Thickson Road Underpass

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

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

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

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

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

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

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

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

ROCK QUALITY: ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND/OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH DRILLED IN THAT CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE NATURALLY FRACTURED CORE PIECES, 4" IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	2"	2" - 12"	1' - 3'	3' - 10'	> 10'
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

#### ABBREVIATIONS & SYMBOLS




##### LABORATORY TESTING

TRIAXIAL TESTS ARE DESCRIBED IN TERMS OF WHETHER THEY ARE CONSOLIDATED (C) OR NOT (U) ISOTROPICALLY (I) OR NOT (A) AND SHEARED DRAINED (D) OR UNDRAINED (U) WITH PORE PRESSURE MEASUREMENTS (BAR OVER SYMBOLS) EG.  $\bar{C}U$  = 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

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

##### INDEX PROPERTIES

$\gamma$  UNIT WEIGHT OF SOIL (BULK DENSITY)  
 $\gamma_w$  UNIT WEIGHT OF WATER  
 $\gamma_d$  UNIT DRY WEIGHT OF SOIL (DRY DENSITY)  
 $\gamma'$  UNIT WEIGHT OF SUBMERGED SOIL  
 $G_s$  SPECIFIC GRAVITY OF SOLIDS  
 $e$  VOIDS RATIO  
 $e_o$  INITIAL VOIDS RATIO  
 $e_{max}$   $e$  IN LOOSEST STATE  
 $e_{min}$   $e$  IN DENSEST STATE  
 $D_r$  RELATIVE DENSITY =  $\frac{e_{max} - e}{e_{max} - e_{min}}$   
 $n$  POROSITY  
 $w$  WATER CONTENT  
 $w_L$  LIQUID LIMIT  
 $w_P$  PLASTIC LIMIT  
 $w_S$  SHRINKAGE LIMIT  
 $I_p$  PLASTICITY INDEX =  $w_L - w_P$   
 $I_L$  LIQUIDITY INDEX =  $\frac{w - w_P}{I_p}$   
 $I_C$  CONSISTENCY INDEX =  $\frac{w_L - w}{I_p}$   
 $A_c$  ACTIVITY =  $\frac{I_p \text{ of soil}}{I_p \text{ of } 2\mu m \text{ Soil Fraction}}$   
 $Om$  ORGANIC MATTER CONTENT  
 $S_r$  DEGREE OF SATURATION  
 $S$  SENSITIVITY =  $\frac{S_u(\text{undisturbed})}{S_u(\text{remoulded})}$

##### STRENGTH PARAMETERS

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

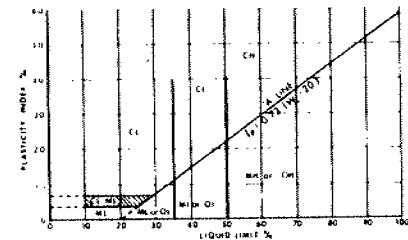
NOTE: EFFECTIVE STRESS PARAMETERS ARE DENOTED BY USE OF APOSTROPHE ABOVE THE SYMBOL, THUS:  
 $Q'$  = EFFECTIVE ANGLE OF SHEARING RESISTANCE;  
 $\sigma'$  = EFFECTIVE NORMAL STRESS

##### HYDRAULIC TERMS

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

# EXTENDED CASAGRANDE SOIL CLASSIFICATION SYSTEM

FIELD IDENTIFICATION PROCEDURES (EXCLUDING PARTICLES LARGER THAN 75 μm AND BASING FRACTIONS ON ESTIMATED MASS)					GROUP SYMBOL	TYPICAL NAMES	INFORMATION REQUIRED FOR DESCRIBING SOILS	LABORATORY CLASSIFICATION CRITERIA								
COARSE GRAINED SOILS MORE THAN HALF OF MATERIAL IS LARGER THAN 75 μm (75 μm IS ABOUT THE SMALLEST PARTICLE VISIBLE TO THE NAKED EYE)	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 SIZES		GW	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES; LITTLE OR NO FINES	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 PARENTHESES.  FOR UNDISTURBED SOILS ADD INFORMATION ON STRATIFICATION, DEGREE OF COMPACTNESS, CEMENTATION, MOISTURE CONDITIONS & DRAINAGE CHARACTERISTICS	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, SM, SP MORE THAN 12% GW, GC, SC, SC BORDERLINE CASES REQ. USE OF DUAL SYMBOLS								
		GRAVEL WITH FINES (APPRECIABLE AMOUNT OF 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		NOT MEETING ALL GRADATION REQUIREMENTS FOR GW	ATTERBERG LIMITS BELOW A-LINE, OR $I_p$ LESS THAN 4	ABOVE A-LINE WITH $I_p$ BETWEEN 4 AND 7 ARE BORDERLINE CASES REQUIRING USE OF DUAL SYMBOLS						
			NON-PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE M. 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 (LITTLE OR NO FINES)	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		FOR UNDISTURBED SOILS AND INFORMATION ON STRATIFICATION, DEGREE OF COMPACTNESS, CEMENTATION, MOISTURE CONDITIONS & DRAINAGE CHARACTERISTICS	$C_u = \frac{D_{60}}{D_{10}}$ GREATER THAN 4 $C_c = \frac{(D_{30})^2}{D_{10} \cdot D_{60}}$ BETWEEN ONE AND 3 NOT MEETING ALL GRADATION REQUIREMENTS FOR SW	ATTERBERG LIMITS BELOW A-LINE OR $I_p$ LESS THAN 4	ABOVE A-LINE WITH $I_p$ BETWEEN 4 AND 7 ARE BORDERLINE CASES REQUIRING USE OF DUAL SYMBOLS					
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	PREDOMINANTLY ONE SIZE OR A RANGE OF SIZES WITH SOME INTERMEDIATE SIZES MISSING		SP	POORLY GRADED SANDS, GRAVELLY SANDS; LITTLE OR NO FINES										
			NON-PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE M. 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											
		IDENTIFICATION PROCEDURES ON FRACTION SMALLER THAN 425 μm														
		FINE GRAINED SOILS MORE THAN HALF OF MATERIAL IS SMALLER THAN 75 μm (75 μm IS ABOUT THE SMALLEST PARTICLE VISIBLE TO THE NAKED EYE)	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 30%	DRY STRENGTH (CRUSHING CHARACTERISTICS)	DILATANCY (REACTION TO SHAKING)						TOUGHNESS (CONSISTENCY NEAR PLASTIC LIMIT)		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 PARENTHESES.  FOR UNDISTURBED SOILS AND INFORMATION ON STRUCTURE, STRATIFICATION, CONSISTENCY IN UNDISTURBED & REMOULDED STATES, MOISTURE & DRAINAGE CONDITIONS.		
NONE	QUICK				NONE	ML										
MEDIUM TO HIGH	NONE TO VERY SLOW				MEDIUM	CL										
SLIGHT TO MEDIUM	SLOW				SLIGHT	OL										
NONE TO SLIGHT	SLOW TO QUICK				SLIGHT	MH										
HIGH	NONE				MEDIUM TO HIGH	CH										
LIQUID LIMIT BETWEEN 30% AND 50%	SLIGHT TO MEDIUM			VERY SLOW	SLIGHT	OL										
	SLIGHT TO MEDIUM			SLOW TO NONE	MEDIUM	MH										
	HIGH TO VERY HIGH			NONE	HIGH	CH										
	MEDIUM TO HIGH			NONE TO VERY SLOW	SLIGHT TO MEDIUM	OH										
	UNKN. CLAYS OF HIGH PLASTICITY															
	PEAT & OTHER HIGHLY ORGANIC SOILS			PL												
HIGHLY ORGANIC SOILS			READILY IDENTIFIED BY COLOUR, ODOUR, SPONGY FEEL & FREQUENTLY BY FIBROUS TEXTURE													



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

## FOUNDATION INVESTIGATION REPORT

For

Thickson Road Underpass  
3.0 Miles West of Oshawa  
W.P. 38-77-02, Site 22-171  
Hwy. 401, District 6, Toronto

### INTRODUCTION

This report contains the result of a foundation investigation carried out at the site of the above mentioned project during the period of February 14 to 16, 1978.

The fieldwork consisted of six sampled boreholes, each accompanied by a dynamic cone penetration test advanced by means of a continuous flight auger machine equipped with a 3 ½ inch I.D. hollow stem and solid stem augers.

The boreholes ranged in depth from 30 to 46 feet below the ground surface.

### SITE DESCRIPTION AND GEOLOGY

The site is located about 3.0 miles west of the City of Oshawa in the Regional Municipality of Durham.

The area is located in the physiographical region known as Iroquois Plain. In this area the subsoil is a mosaic of till plains, drumlins and areas of silty lacustrine deposits.

### SUBSURFACE CONDITIONS

Subsurface conditions at the site were found to be generally uniform. The original ground, under a 1 ft. layer of topsoil, is a glacial till, composed of a hard heterogeneous mixture of silty clay, sand and gravel changing with depth to a very dense heterogeneous mixture of silt, sand and gravel.

The lower boundary of the glacial till stratum was not proven at any of the boring locations but was explored to a maximum depth of 31.5 feet below the existing ground surface. The existing Thickson Road embankment is composed of fill material which is borrowed parent material composed of cohesive glacial till.

A detailed description of the soil encountered in each borehole is given in the Record of Borehole Sheets. The estimated stratigraphical profile and sections shown on Drawing No. 2 are based upon this information. From ground level downwards, the subsurface conditions are as follows:

#### Fill Material

Two boreholes (B.H. 1 and 5) were carried out through the embankment of the existing Thickson Road at the north and south side of the site. The thickness of the fill material was found to be about 15 feet. The fill material is comprised of a cohesive glacial till (heterogeneous mixture of silty clay, sand and gravel). The upper 6 to 8 feet of the fill material contains traces of organics.

Standard Penetration Tests gave "N" values in the range of 5 to 22 blows per foot, indicating that the fill material has a firm to very stiff consistency.

Glacial Till: (Heterogenous Mixture of Silty Clay, Sand and Gravel Changing to a Heterogeneous Mixture of Silt, Sand and Gravel).

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Under a 1 foot thick layer of topsoil or immediately under the fill material is a deposit of glacial till. The deposit is composed of a cohesive heterogeneous mixture of silty clay, sand and gravel changing with depth to a granular heterogeneous mixture of silt, sand and gravel. The boundaries between the upper slightly cohesive portions and lower noncohesive portions of this deposit are difficult to define exactly.

The physical properties of the upper slightly cohesive glacial till as determined from laboratory testing are summarized below:

		<u>Range</u>	<u>Average</u>
Liquid Limit	(W <sub>L</sub> )%	12-15	14
Plastic Limit	(W <sub>P</sub> )%	9-13	11
Plasticity Index	(I <sub>P</sub> )%	1-5	3
Moisture Content	(W) %	5-9	7

The results of the Atterberg Limit Tests are shown on the Plasticity Chart on Figure 1. These results indicate that the matrix is inorganic and of low plasticity. (CL-ML to ML zone)

The result of grain size distribution testing performed on representative samples from the overall glacial till deposit are shown in an envelope form on Figure 2 of the Appendix.

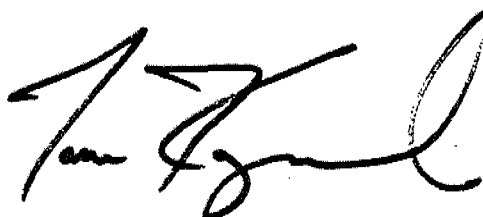
The Standard Penetration Tests gave "N" values in the range of 31 to over 100 blows per foot, generally increasing with depth. Based on these "N" values the consistency of this slightly cohesive stratum is estimated to be hard, whereas the relative density of the lower noncohesive portion of the glacial till has a dense to very dense relative density, generally in the very dense range.

The lower boundary of this glacial till deposit was not established, but was proven to a maximum of 32 feet.



Groundwater

The groundwater level conditions were observed by measuring in the open boreholes during and after the completion of the foundation investigation. The groundwater level was found to vary between elevation 282.0 (B.H. 3) and 310.0 (B.H. 2) which corresponds to 12 to 45 ft. below the existing ground surface. The groundwater levels are shown on the Record of Borehole Sheets, as well as on Drawing No. 2.



Tom Kazmierowski, P. Eng.  
Foundations Engineer



M. Devata, P. Eng.  
Senior Foundations Engineer

## APPENDIX

RECORD OF BOREHOLE No 1

9

W P 38-77-02 LOCATION Co-ords. N. 15,940,906; E 1,56,759 ORIGINATED BY V.K.  
DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY V.K.  
DATUM Geodetic DATE February 14, 1978 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100							
								SHEAR STRENGTH							
							○ UNCONFINED + FIELD VANE			WATER CONTENT (%)					
							● QUICK TRIAXIAL x LAB VANE			10 20 30					
329.0	Ground Level													GR SA SI CL	
0.0	Fill		1	SS	10									4 44 36 16	
	Clayey Silt with sand and traces of gravel and organic		2	SS	5										
	Firm to Stiff		3	SS	11									3 31 36 30	
313.0			4	SS	31										
16.0	Glacial Till		5	SS	100	/5"				○	I				
	Het. Mix. Clayey		6	SS	110	/10"				○	I			21 39 27 13	
	Silt Sand and Gravel Hard		7	SS	50					○	I				
	Brown - Changing to		8	SS	95	/9"				○	I				
	Grey Het. Mix. Silt		9	SS	129					○	NP			8 43 43 6	
	Sand and Gravel														
	V. Dense														
283.2			10	SS	126	/9"									
45.8	End of Borehole														

RECORD OF BOREHOLE No 2

W P 38-77-02 LOCATION Co-ords. N. 15,940,935; E 1,156,861 ORIGINATED BY V.K.  
DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY V.K.  
DATUM Geodetic DATE February 14, 1978 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40						60	80	100
								SHEAR STRENGTH							WATER CONTENT (%)		
322.2	Ground Level													GR SA SI CL			
0.0	Topsoil																
	Glacial Till		1	SS	53												
	Het. Mix. Claye Silt		2	SS	153	/11"								6 42 42 10			
	Sand and Gravel		3	SS	137												
	Hard		4	SS	79												
	Changing to Het. Mix.		5	SS	156									7 35 43 15			
	Silt, Sand and Gravel		6	SS	157												
	V. Dense		7	SS	171	/9"											
	Brown - Grey		8	SS	100	/3"								4 25 57 14			
293.0																	
29.2	End of Borehole																

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE



Ministry of  
Transportation and  
Communications

HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 3

10

W P 38-77-02 LOCATION Co-ords. N. 15,940,779; E. 1,156,791 ORIGINATED BY V.K.  
DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY V.K.  
DATUM Geodetic DATE February 16, 1978 CHECKED BY [Signature]

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
309.2	Ground Level													
0.0	Topsoil													
	Glacial Till		1	SS	35									
	Het. Mix. Clayey Silt, Sand and Gravel		2	SS	77									
	Hard		3	SS	81									
			4	SS	174	/10"								
			5	SS	156									
	Brown Grey		6	SS	184	/11"								
	Changing to Het. Mix. silt sand and gravel.		7	SS	181	/10"								
	Very Dense		8	SS	183	/6"								
278.7														
30.5	End of Borehole													

RECORD OF BOREHOLE No 4

W P 38-77-02 LOCATION Co-ords. N. 15,940,833; E 1,156,888 ORIGINATED BY V.K.  
DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY V.K.  
DATUM Geodetic DATE February 16, 1978 CHECKED BY [Signature]

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
312.5	Ground Level													
0.0	Topsoil													
	Glacial Till		1	SS	49									
	Het. Mixture of Clayey Silt, Sand and Gravel		2	SS	121	/10"								
	Hard		3	SS	76									
	Changing to Het. Mix. Silt, Sand and Gravel		4	SS	100	/5"								
	V. Dense		5	SS	144	/11"								
			6	SS	153	/10"								
			7	SS	101									
281.0														
31.5	End of Borehole													

\*3, x5: Numbers refer to  
Sensitivity

20  
15  $\phi$  5 (%) STRAIN AT FAILURE  
10

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 5

11

W P 38-77-02 LOCATION Co-ords. N. 15,940,677; E. 1,156,833 ORIGINATED BY V.K.  
DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY V.K.  
DATUM Geodetic DATE February 15, 1978 CHECKED BY *dp*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						
329.0	Ground Level													GR SA SI CL
0.0	Fill Clayey silt with sand and some gravel and traces of organics		1	SS	22									16 37 32 15
			2	SS	12									0 43 39 18
			3	SS	7									
314.0	Firm to V. Stiff		4	SS	9									
15.0	Glacial Till Het. Mixture of Clayey Silt, Sand and Gravel		5	SS	37									26 35 29 10
	Hard brown grey		6	SS	133									
			7	SS	153									10 37 43 10
	Changing to Het. Mixture of Silt Sand and gravel		8	SS	145									
	V. Dense		9	SS	126									
282.5			10	SS	91									
46.5	End of Borehole													

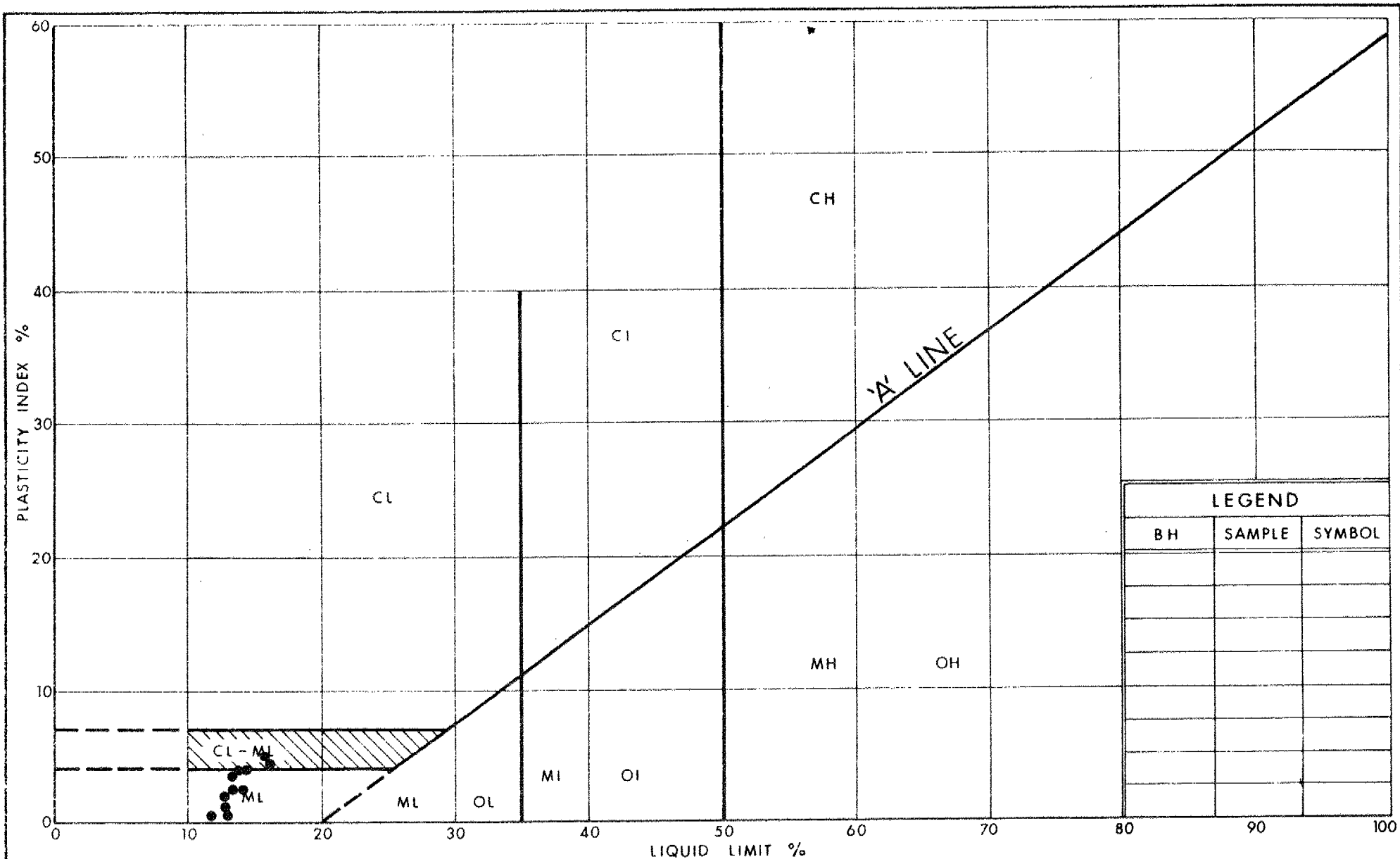
RECORD OF BOREHOLE No 6

W P 38-77-02 LOCATION Co-ords. N. 15, 940,706; E 1,156,934 ORIGINATED BY V.K.  
DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY V.K.  
DATUM Geodetic DATE February 15, 1978 CHECKED BY *dp*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						
321.0	Ground Level													GR SA SI CL
0.0	Topsoil													
	Glacial Till		1	SS	129									13-36-31 20
	Het. Mixture Clayey Silt Sand and Gravel		2	SS	122	/11"								
	Hard		3	SS	120	/11"								28 34 29 9
	Changing to Het. Mixture of Silt Sand and Gravel		4	SS	115	/11"								
			5	SS	162									
	V. Dense		6	SS	154	/10"								
			7	SS	192	/9"								7 43 41 9
290.5			8	SS	94									
30.5	End of Borehole													

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

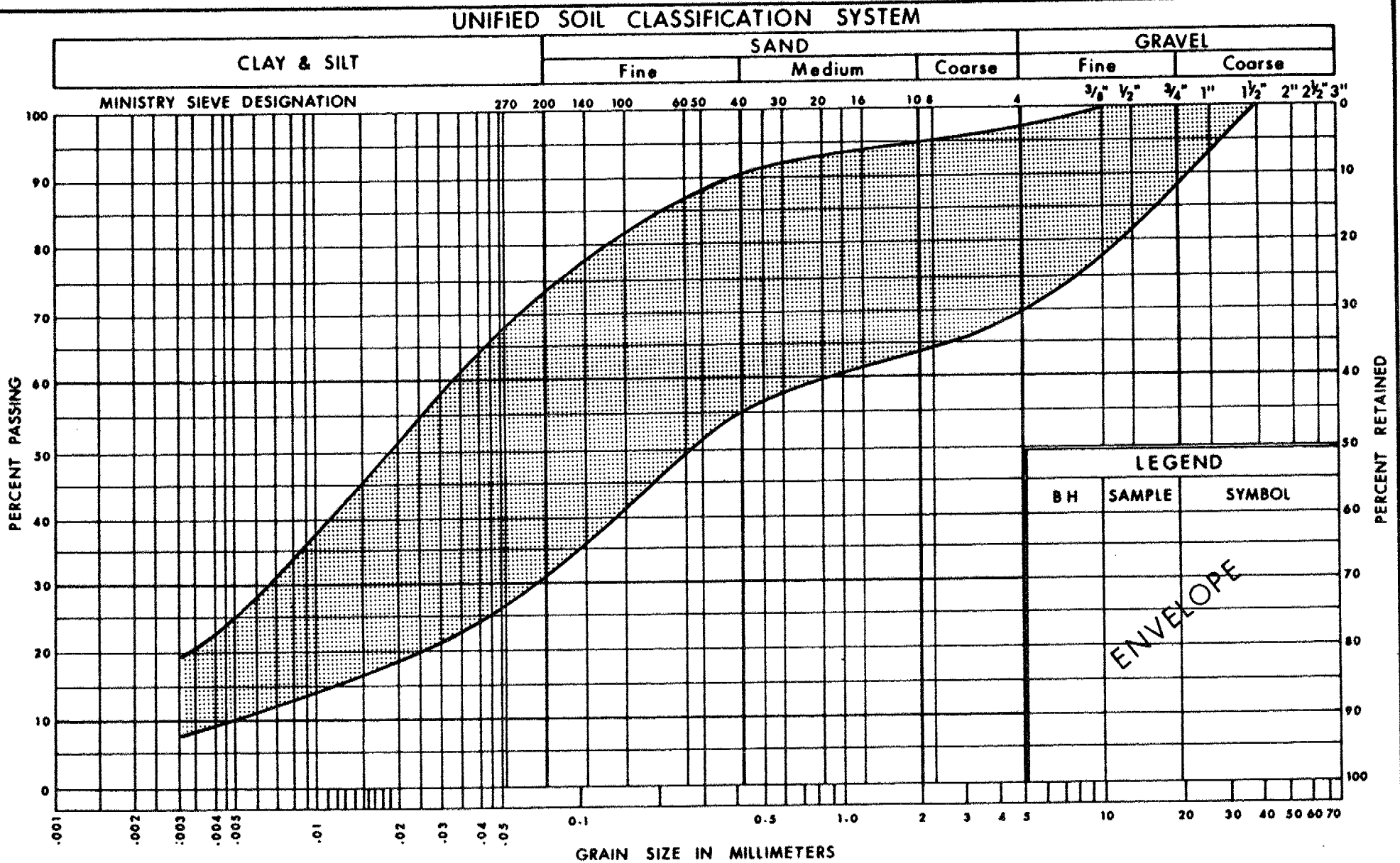


Ministry of  
Transportation and  
Communications

PLASTICITY CHART  
GLACIAL TILL  
SLIGHTLY COHESIVE PORTION

FIG No 1

W P 38-77-02







SAMPLE DISPOSITION NOTICE		
TYPE	DISCARD AFTER	RECOMM. BY
JARS	80 03 31	M. L.
TUBES	80 03 31	M. L.
ROCK CORES	—	—

ENGINEERING MATERIALS OFFICE  
PAVEMENT & FOUNDATION DESIGN SECTION

WP 38-77-01 DIST 6  
HWY 401 STR SITE

West Corbett Creek Culvert Replacement  
Hwy. 401 and Thickson Road Interchange

DISTRIBUTION

G.C.E. Burkhardt (3)  
R.D. Gunter  
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R. Fitzgibbon )  
J. Anderson ) Cover Only  
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cont. 82-72

GEOCRES 30M15-52

DATE MAR 04 1980

## FOUNDATION INVESTIGATION REPORT

For

West Corbett Creek Culvert Replacement,  
Hwy. 401 and Thickson Road Interchange  
W.P. 38-77-01, District 6, Toronto

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### INTRODUCTION

This report summarizes the results of a foundation investigation program carried out at the above mentioned site and presents recommendations pertaining to the design and construction of the proposed culvert extensions and embankment fills. The fieldwork was performed from 1979-12-17 to 18 and consisted of 2 sampled boreholes advanced by continuous flight hollow stem augers to depths of 36.0 and 47.0 feet.

In addition, information from one boring and dynamic cone penetration test carried out on 1976-10-29 to a depth of 51.7 feet and detailed under W.P. 44-71-20 are included in this report.

### SITE DESCRIPTION

The site is located approximately 1000 feet west of the existing Hwy. 401 and Thickson Road Interchange, where Hwy. 401 crosses over the West Corbett Creek. This location is in the Town of Whitby, Regional Municipality of Durham.

In general, the West Corbett Creek drains the surrounding fields and joins with the East Corbett Creek before they empty into Lake Ontario about a mile and a half southeast of the site.

Presently the West Corbett Creek is carried beneath Hwy. 401 and the North and South Service Roads via 3 separate 10' x 6' open concrete box culverts. The existing Hwy. 401 culvert shows significant settlements with a prominent sag in the longitudinal profile resulting in excessive silting within the culvert section.

Topographically, the area is flat to gently undulating, generally sloping down to the creek from the east and the west.

Physiographically, the site is located in the region referred to as the "Iroquois Plain". This is the lowland bordering Lake Ontario which was inundated in the Pleistocene time by Lake Iroquois. Subsoils in this area generally consist of lacustrine deposits overlying glacial till.

#### SUBSURFACE CONDITIONS

Reasonably uniform subsoils were encountered in borings at the culvert extension locations. Overlying the locations is a shallow surficial deposit of silty clay with some sand and organics extending for depths of 4.5 to 9.0 feet. The predominant soil strata underlying the site is a highly compressible banded silty clay to clay deposit explored for approximately 36.0 feet. Underlying this cohesive deposit and explored to a maximum depth of 13 feet is a silty sand deposit.

The boundaries between the various subsoil types, as well as location, elevations, and test results are shown on the attached Record of Borehole Sheets.

A brief description of the various subsoils encountered follows.

##### Silty Clay

A shallow surficial deposit consisting of silty clay of low plasticity with some sand and organics was found to extend for depths ranging from 4.5 to 9.0 feet. Occasional silt inclusion throughout plus organics and root structures were encountered in this deposit. Standard Penetration Test 'N' values ranging from 4 to 7 blows/ft. in addition to visual identification indicate this surficial deposit to have a consistency ranging from soft to stiff, but generally firm throughout.

### Silty Clay to Clay

The predominant subsoil type encountered in the borings is a glaciolacustrine deposit consisting of banded silty clays and clays. Random mottling with irregular silt inclusions were found throughout this deposit. This cohesive stratum was found to extend for depths ranging from 30 to 36.5 feet.

Laboratory and in-situ testing performed on representative samples from this deposit gave the following results:

<u>Index Properties</u>	(8 Tests)	<u>Range</u>	<u>Average</u>
Natural Moisture Content	(w) %	25-55	40
Liquid Limit	(w <sub>L</sub> ) %	36-55	43
Plastic Limit	(w <sub>p</sub> ) %	14-18	16
Plasticity Index	(I <sub>p</sub> ) %	21-37	27

### Consolidation Testing (2 Tests)

Degree of Preconsolidation ( $\sigma'_p - \sigma'_{v_o}$ )	t.s.f.	0.56,	0.61
Initial Void Ratio	(e <sub>o</sub> ) %	1.5,	1.6
Coefficient of Consolidation (C <sub>c</sub> )		1.2,	1.4

The results of the Atterberg Limit Testing are shown on the Plasticity Chart, Figure 2 and indicate the deposit to be an inorganic silty clay to clay of medium to high plasticity, generally varying due to the highly banded structure of the deposit. The stratum is moderately sensitive to remoulding as confirmed by sensitivity values ranging from 4 to 7 and generally 4 to 9, as measured by the lab vane and field vane testing respectively.

Two consolidation tests were performed on samples from this deposit and are summarized on Figure 3. This testing indicates that the banded clay deposit has been preconsolidated by a pressure of 0.56 to 0.61 t.s.f. in excess of the existing effective overburden pressure. Based on the results of e<sub>o</sub> and C<sub>c</sub>, the banded clay deposit can be described as lightly consolidated and highly compressible. Upon loading in excess of the preconsolidation pressure, this stratum will undergo significant consolidation resulting in excessive settlements.

In-situ vane testing and laboratory vane, unconfined compression, and quick triaxial testing (refer to appended Record of Borehole Sheets) resulted in undrained shear strength values ranging from 100 to in excess of 1500 p.s.f., but averaging in the range of 100 to 500 p.s.f. below the weathered or desiccated upper portion of the stratum. These results indicate the deposit to have a very soft to soft consistency.

#### Silty Sand

Underlying the glaciolacustrine clay deposit and penetrated for a maximum depth of 13.5 feet is a deposit of silty sand with a trace of clay and gravel. 'N' values ranging from 3 to 5 blows/ft. indicate this deposit has a very loose denseness.

#### Groundwater Conditions

Generally, groundwater levels over the site can be assumed to reflect creek water levels. Water levels in the West Corbett Creek at the time of the field investigation were found to be at elevation 272.

Two water samples were taken from the West Corbett Creek and submitted for testing to determine their aggressiveness to concrete. The results are appended in memo form and indicate that the present creek water will not affect the quality of concrete.

## DISCUSSION AND RECOMMENDATIONS

As part of the Hwy. 401/Thickson Road Interchange improvement plan it is proposed to upgrade the existing culvert configuration carrying the West Corbett Creek beneath Hwy. 401 and replace the existing Service Roads with two interchange ramps. Two schemes are proposed for the culvert reconstruction:

Scheme #1 - Maintain the existing 6' x 10' concrete box culvert and replace the existing 6' x 10' culvert beneath the north and south Service Roads with either a 10' x 16' concrete box culvert or equivalent twin C.S.P. connected to the Hwy. 401 culvert.

Scheme #2 - Replace all the existing box culverts under the Service Roads and Hwy. 401 with twin corrugated steel pipes.

Proposed profile grades for the ramps will require fill heights in the order of 25 feet for Ramp W-NS and 15 feet for Ramp N-W.

In view of the very soft and highly compressible nature of the underlying subsoils at the culvert locations, the stability of the embankment fills as well as settlements caused by the additional surcharging of the subsoils by the proposed height of ramp fills will be discussed first.

### Stability of Ramp Embankment

In order to ensure the stability of the southern portion of the Ramp N-W, S embankment and the northern portion of the Ramp N-W embankment against a deep seated rotational-type of failure, the following recommendations based on stability analysis in terms of total stress are presented.

For embankments constructed using lightweight fill, i.e. air-dried slag or bottom ash, with a maximum compacted unit weight of 90 p.c.f. and minimum angle of internal friction of  $\phi = 35^\circ$ , embankment slopes of a minimum 2H:1V for both ramp geometries

were found to have an adequate factor of safety against a rotational type of failure. Use of the lightweight fill should extend for a minimum distance of 100 feet on either side of the creek for the full sectional geometry of both ramp embankments. Refer to the attached memo from the Geotechnical Section, Central Region for availability of lightweight fill material.

Although ramp embankments composed of normal fill material can be constructed, they will require extensive berms resulting in additional property acquisition which we understand to be impractical at the present time. In addition, excessive differential settlements are anticipated within the culvert sections with the use of the heavier normal fill material.

The recommendations with regards to ramp fill material and slope geometry pertain only to the immediate culvert extension area where the field investigation has to be carried out by this Section.

#### Consolidation Settlement of Culverts

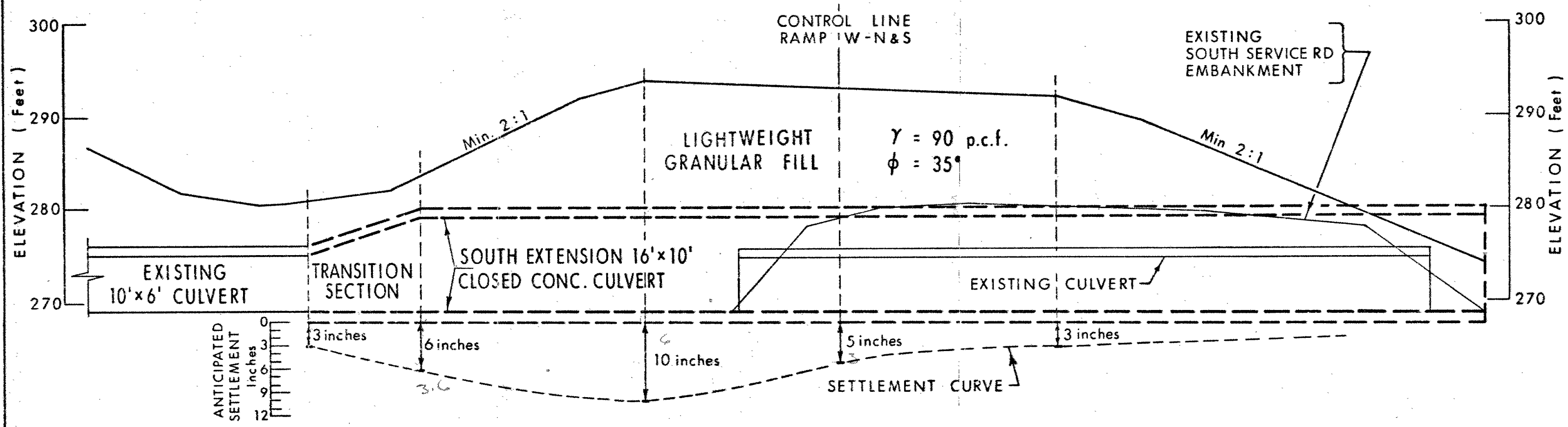
Analyses of vertical stress increase and anticipated consolidation settlements were carried out to assess differential vertical movements between various culvert elements resulting from nonuniform surcharging of the highly compressible subsoils beneath the proposed geometries of the ramp embankments. Results indicated that embankments constructed of normal weight fill material would cause excessive settlements beneath the culvert extension segments. In addition, embankments constructed of acceptable lightweight fill material would still result in settlements ranging from 0.6 feet to 1.8 feet within the individual culvert segment.

In order to prevent these excessive differential settlements within the culvert extension sections it is recommended to remove the existing service road fills and preload the site to the full ramp geometry using lightweight fill a minimum of 6 months prior to construction of the culvert extensions. This will insure that 50% of the total consolidation settlement will occur prior to culvert placement. Provided culvert

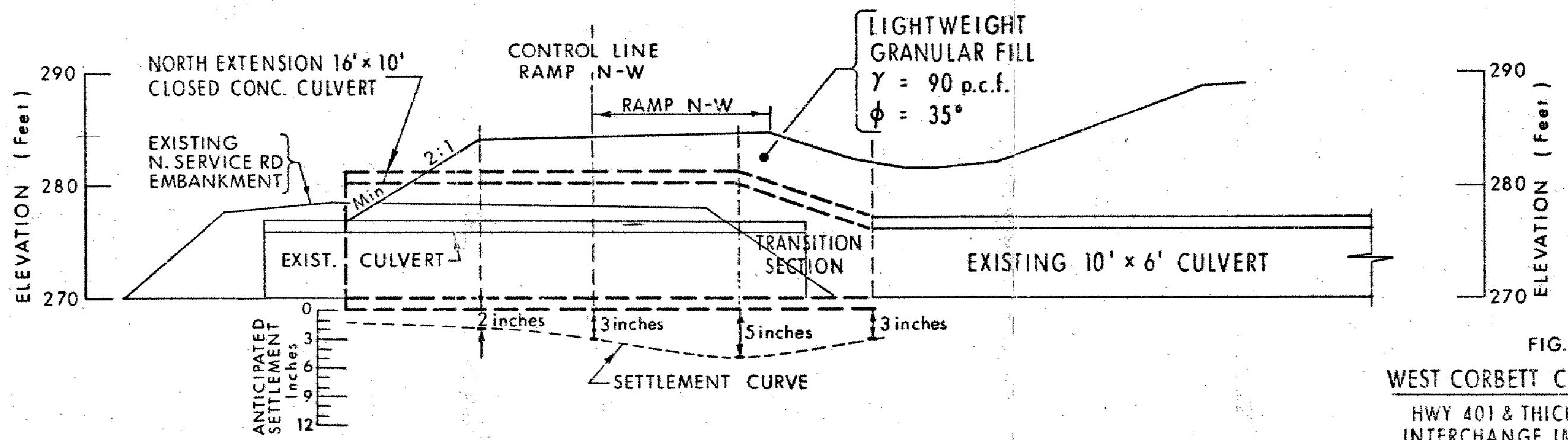
sites are preloaded as recommended, anticipated consolidation settlements between the various culvert segments are shown on Figure 1. These settlements can be accommodated by allowing sufficient camber in the grade of the culvert.



ANTICIPATED CONSOLIDATION SETTLEMENTS BENEATH VARIOUS CULVERT SEGMENTS  
AFTER PRELOADING USING LIGHTWEIGHT AGGREGATE



LONGITUDINAL CROSS SECTION - SOUTH CULVERT EXTENSION



LONGITUDINAL CROSS SECTION - NORTH CULVERT EXTENSION

FIG. 1  
WEST CORBETT CREEK CULVERT  
HWY 401 & THICKSON ROAD  
INTERCHANGE IMPROVEMENT  
HOR. SCALE: 1"=10' WP 38-77-01

### Culvert Foundations

In consideration of the very soft and highly compressible subsoils underlying the site, our recommendations pertaining to culvert foundations for the two schemes are as follows:

#### Scheme #1

The proposed concrete box culvert should be founded on a 3 foot thick well compacted Granular 'A' pad extending for a minimum 5 feet on either side of the culvert. This will insure a uniform stress distribution beneath the culvert and prevent overstressing of the underlying subsoils. For the proposed twin C.S.P., this Granular 'A' pad should be shaped to provide adequate support beneath the pipe sections. Lightweight granular cover and backfill material must be properly compacted at the pipe hunches and around the pipe as per M.T.C. Standards DD-813-A.

Joints between the transition culvert sections and the existing and extended culvert sections should be designed to allow for vertical movements between the individual culvert sections.

Cut slopes within the lightweight ramp fills required for culvert placement after preloading must be maintained at a minimum of 2H:1V.

#### Scheme #2

Complete removal of the existing culvert geometry and replacement with two 11'  $\phi$  metal pipe utilizing open cut techniques is not practical due to anticipated instability of the existing Hwy. 401 embankment. For preliminary design estimating purposes, the twin pipes can be installed in a sheeted and braced excavation. Sheet piling will have to be driven through the existing Hwy. 401 fill for a minimum of 40 feet below the base of the excavation and properly braced to resist lateral forces. Alternatively the two pipes can be installed utilizing tunnelling techniques and by hydraulically pushing the pipes through the Hwy. 401 fills. In order to ascertain the exact depth of sheeting penetration and design parameters for the existing Hwy. 401 fill material, additional borings will be required through the Hwy. 401 embankment for detailed design

purposes. This section will carryout this investigation provided Scheme #2 is approved.

#### Construction Considerations

Excavation of the existing service road fills prior to preloading the site using lightweight fill should be carried out in transverse sections with a minimum base width not greater than 25 feet. Each section should be backfilled with lightweight fill before excavation of the next section commences. This staged excavation should be carried out for the full 200 feet of treatment on both ramps.

All organic and deleterious material should be excavated from beneath the pipe and backfilled with a well compacted free-draining granular material within the limits of the proposed compacted Granular 'A' pad.

#### MISCELLANEOUS

The fieldwork for this report was carried out under the supervision of Mr. T.J. Kazmierowski, Project Foundations Engineer, using equipment rented from Dominion Soil Investigation Inc., Toronto.

This report was prepared by Mr. T.J. Kazmierowski and reviewed by Mr. M. Devata, Senior Foundations Engineer.



*M Machen*  
for

T.J. Kazmierowski  
Project Foundations Engineer

*M Devata*

M. Devata  
Senior Foundations Engineer

## APPENDIX 1



Ministry of  
Transportation and  
Communications

HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 1

W P 38-77-01 LOCATION Sta. 302 + 73, 0/S 112' Lt. # Hwy. 401 ORIGINATED BY T.J.K.  
DIST 6 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY T.J.K.  
DATUM Geodetic DATE Dec. 17, 1979 CHECKED BY AS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
275.0	Ground Surface																
0.0	Silty Clay orge. and Trace Sand root structure		1	SS	7												
269.0	- Occ. Silt Inclusions Firm		2	SS	5												
6.0	Silty Clay weathered to Clay		3	SS	4												
	Medium Plasticity		4	TW	PH												
	- Occ. Banded Structure		5	TW	PM												
	- Random Mottling of Silt Inclusions		6	TW	PM												
	Very Soft to Soft		7	TW	PM												
			8	SS	3												
241.5																	
33.5	Silty Sand		9	SS	3												
	Trace of Clay and Gravel		10	SS	5												
	Very Loose																
228.0			11	SS	-												
47.0	End of Borehole																

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 2

W P 38-77-01 LOCATION Sta. 302 + 79, 0/S 117' Rt. 6 Hwy. 401 ORIGINATED BY T.J.K.  
DIST 6 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY T.J.K.  
DATUM Geodetic DATE Dec. 18, 1979 CHECKED BY AS

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ pcf	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20 40 60 80 100	100	Wp	W	WL		
273.5	Ground Surface												
0.0	Silty Clay Low Plasticity With Sand Some Organics and Root Struc. Firm		1	SS	5								
			2	SS	4								
269.0			3	SS	5								
4.5			4	TW	PH								
	Weathered												
	Silty Clay to Clay												
	Medium Plasticity		5	TW	PH								
	-Banded Structure												
	-Random Mottling With Irregular Silt Inclusions		6	TW	PH								
	Very Soft to Soft												
			7	SS	3								
			8	SS	4								
243.5													
30.0	Silty Sand Trace Gravel and Clay Very Loose		9	TW	PH								
			10	SS	3								
237.5													
36.0	End of Borehole												

3, x 5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

OFFICE REPORT ON SOIL EXPLORATION



**RECORD OF BOREHOLE No 9** (Formerly W.P. 44-71-20)

W P 38-77-01 LOCATION Sta. 302 + 06, O/S 200' LT @ Hwy. 401 ORIGINATED BY T.L.  
 DIST 6 HWY 401 BOREHOLE TYPE Hollow Stem Augers & Cone COMPILED BY R.S.  
 DATUM Geodetic DATE October 29, 1976 CHECKED BY RS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
275.5	Ground Surface													
0.0	Organics and Silty Clay with Occasional Shell Fragment and Undecayed Organics		1	SS	4									
	Firm to Stiff		2	SS	4									
266.5														
9.0	Silty Clay		3	TW	PH									
	Sensitive Grey		4	TW	PM									
	Occasional Silt Seams													
	Soft to Firm		5	TW	PM									
			6	TW	PH									
			7	TW	PH									
			8	TW	PH									
239.0														
36.5	End of Borehole													
223.8														
51.7	End of Cone Test													

SHEAR STRENGTH PSF  
 ○ UNCONFINED + FIELD VANE  
 • QUICK TRIAXIAL • LAB VANE  
 200 400 600 800 1000

WATER CONTENT (%)

1520 +

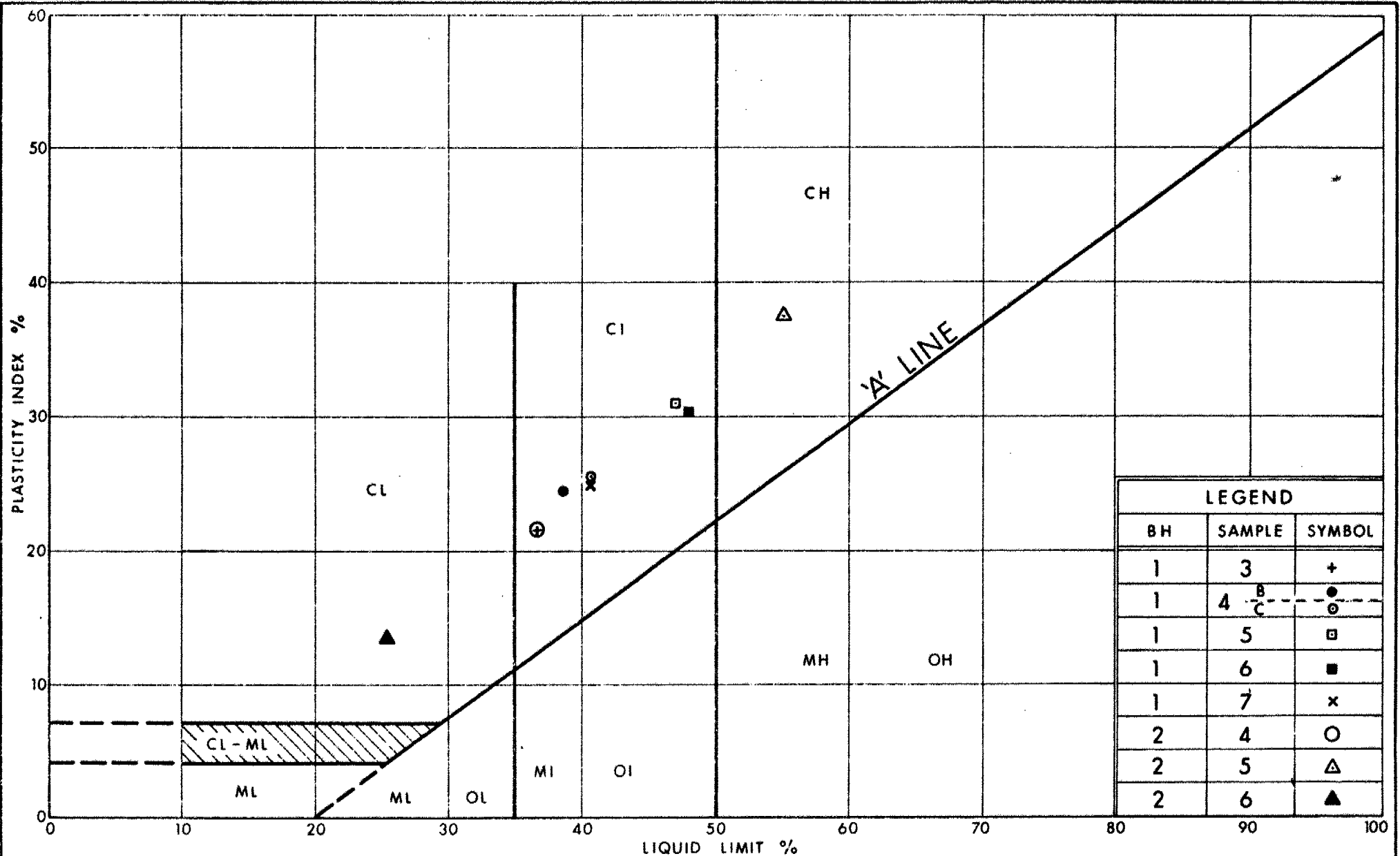
1400 +

120/5"

**+3, x5 : Numbers refer to Sensitivity**

20  
15  $\phi$  5 (%) STRAIN AT FAILURE  
10

10



Ontario

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Communications

# PLASTICITY CHART SILTY CLAY

FIG No 2

W P 38 - 77 - 01



# VOID RATIO - PRESSURE CURVES

WP 38 - 77 - 01

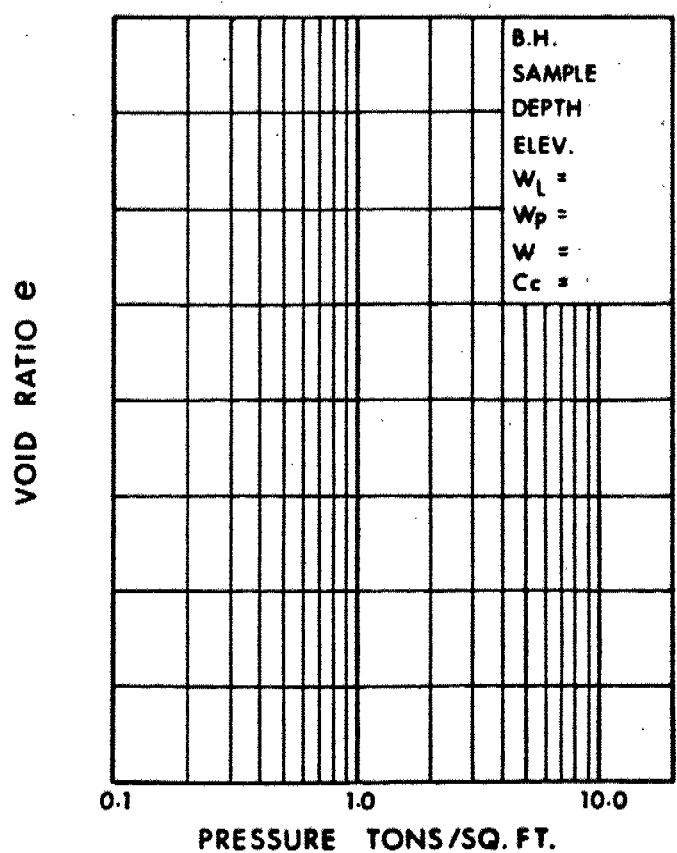
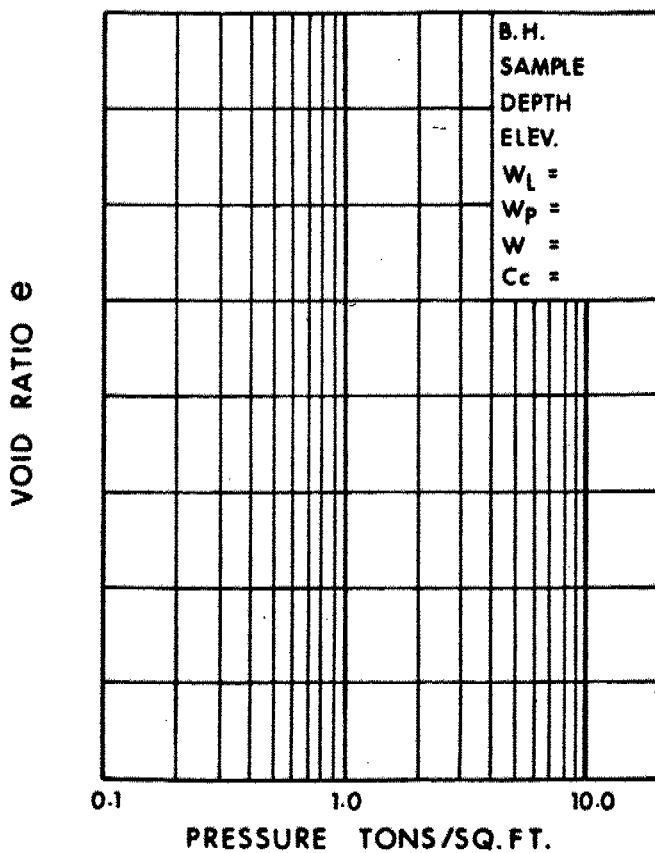
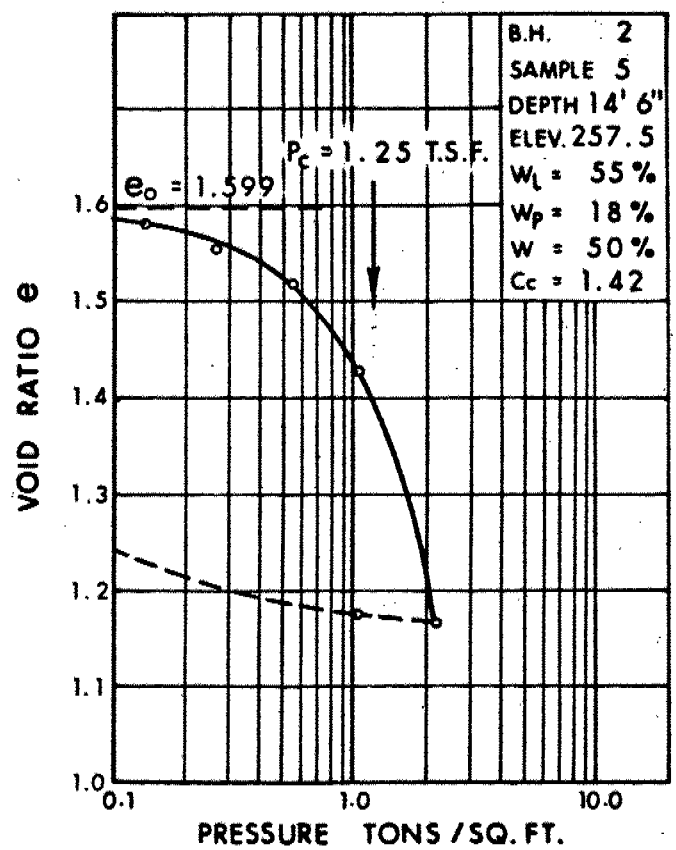
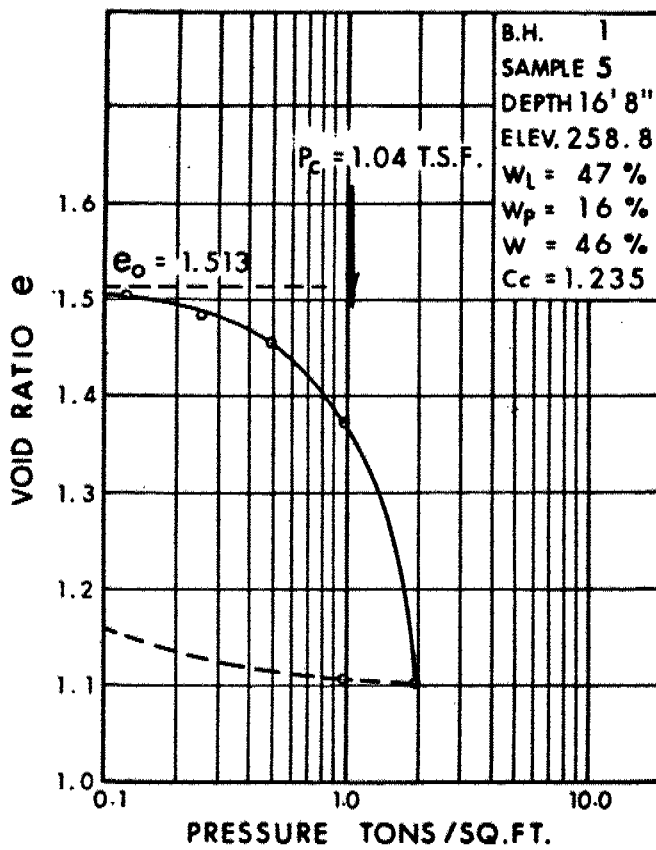


FIG. 3

## APPENDIX 2

# memorandum



To: Mr. T. Kazmierowski,  
Project Foundation Engineer,  
Pavement & Foundation Design Section,  
Central Building, Room 313.

Date: 80 01 10  
File No: 3162-2-2-314

From: Engineering Materials Office,  
Chemicals Section,  
Central Building, Room 105.


## Concrete Mix and Foundations

-----

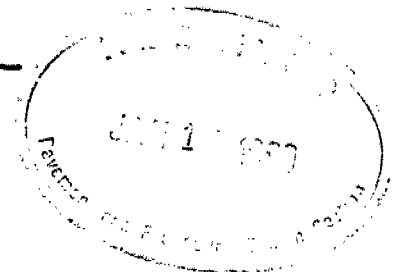
Attached are the test results of two water samples of which you requested to determine their aggressiveness to concrete.

The test results show that:

- The pH values indicate slightly alkaline waters considered non-aggressive to concrete.
- The chloride contents are somewhat elevated. This indicates that the samples are salt contaminated. In my opinion, the chlorides are not sufficiently high to cause any harm to concrete. However, it should be realized that the chlorides will slowly penetrate the concrete (depending on porosity) and will initiate corrosion of the re-inforcement if this is present.
- The iron contents are harmless.
- The Concrete Manual rates a concentration of 0-150 ppm  $\text{SO}_4$  as having a negligible degree of sulphate attack. The sulphate concentrations determined in the samples are, therefore, harmless.

  
R. A. Sterk,  
Head,  
Chemicals Section.

RAS:ma



( )

Test Results of Water Samples

-----

Chem. Lab. Number	79-13010	79-13011
Soils Lab. Number	32934	32935
pH	8.6	8.4
Chloride (ppm Cl')	138	148
Iron (ppm Fe)	0.2	0.2
Sulphate (ppm SO <sub>4</sub> )	62	66



## Memorandum

To: M. Devata  
Soil Mechanics Office  
Main Floor, West Bldg.

From: Regional Geotechnical Section  
Central Region

Attention: T. Kazmierowski

Date: 80 01 22

Our File Ref.

In Reply to

Subject:

W.P. 38-77-01, Hwy. 401/Thickson Rd.  
Unit Weight (Density) for  
Bottom Ash, Fly Ash Mix  
(Bottom Ash and Fly Ash)  
and Pit-run Slag



Further to our verbal conversation of January 18, 1980, concerning the unit weights for the above materials, I am forwarding the following comments and densities for the Bottom ash, Fly ash mix (Bottom ash and Fly ash) and pit-run slag:

We received two typical compaction tests from London Region, one for Fly ash and one for mix ash. The maximum Dry Density for the mix ash is 86.4 P.C.F. and the maximum Dry Density for the Fly ash is 73.9 P.C.F.

One compaction test report was received from the National Slag (copy attached) where the maximum Dry Density varies from 82 to 89 P.C.F.

The quality control office in Central Region have carried out many compaction tests for the Bottom ash. The maximum Dry Density varies from less than 80 P.C.F. to over 110 P.C.F.

After lengthy discussion with the quality control office and reviewing many test samples, we came to the conclusion that for your calculation, the following unit weights should be used:

- 1) Unit weight for Bottom ash use 90 pounds per cubic foot.
- 2) Unit weight for Fly ash use 85 pounds per cubic foot.

Continued.... /2

- 3) Unit Weight for mix ash use 90 pounds per cubic foot.
- 4) Unit weight for pit-run slag (as per report of National Slag of 82 to 89 P.C.F.) use 85 pounds per cubic foot.

The Bottom ash and Fly ash is available from the Ontario Hydro plant in Etobicoke and the pit run slag from National Slag in Hamilton.

AS/RDG:bc

  
A. Shopoff

For: R.D. Gunter  
Head, Geotechnical Section

c.c. G. Celmins  
G. Burkhardt  
A. Teoh - Delcan  
G. Wrong

# 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. 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

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

### INDEX PROPERTIES

$\gamma$  UNIT WEIGHT OF SOIL (BULK DENSITY)  
 $\gamma_w$  UNIT WEIGHT OF WATER  
 $\gamma_d$  UNIT DRY WEIGHT OF SOIL (DRY DENSITY)  
 $\gamma'$  UNIT WEIGHT OF SUBMERGED SOIL  
 $G_s$  SPECIFIC GRAVITY OF SOLIDS  
 $e$  VOIDS RATIO  
 $e_o$  INITIAL VOIDS RATIO  
 $e_{max}$   $e$  IN LOOSEST STATE  
 $e_{min}$   $e$  IN DENSEST STATE  
 $D_r$  RELATIVE DENSITY =  $\frac{e_{max} - e}{e_{max} - e_{min}}$   
 $n$  POROSITY  
 $w$  WATER CONTENT  
 $w_L$  LIQUID LIMIT  
 $w_P$  PLASTIC LIMIT  
 $w_S$  SHRINKAGE LIMIT  
 $I_P$  PLASTICITY INDEX =  $w_L - w_P$   
 $I_L$  LIQUIDITY INDEX =  $\frac{w - w_P}{w_P - w_L}$   
 $I_C$  CONSISTENCY INDEX =  $\frac{w_L - w}{w_P - w_L}$   
 $A_c$  ACTIVITY =  $\frac{I_P \text{ of soil}}{I_P \text{ of } 2\mu m \text{ Soil Fraction}}$   
 $Om$  ORGANIC MATTER CONTENT  
 $S_r$  DEGREE OF SATURATION  
 $S$  SENSITIVITY =  $\frac{S_u \text{ (undisturbed)}}{S_u \text{ (remoulded)}}$

### STRENGTH PARAMETERS

$\phi$  ANGLE OF SHEARING RESISTANCE  
 $\tau_f$  PEAK SHEAR STRENGTH  
 $\tau_R$  RESIDUAL SHEAR STRENGTH  
 $c$  COHESION INTERCEPT  
 $\sigma_1, \sigma_2, \sigma_3$  NORMAL PRINCIPAL STRESSES  
 $u$  PORE WATER PRESSURE  
 $u_e$  EXCESS  $u$   
 $r_u$  PORE PRESSURE RATIO  
 $q_u$  UNCONFINED COMPRESSIVE STRENGTH  
 $s_u$  UNDRAINED SHEAR STRENGTH  
 $\epsilon$  LINEAR STRAIN  
 $\gamma$  SHEAR STRAIN  
 $\nu$  POISSON'S RATIO  
 $E$  MODULUS OF ELASTICITY  
 $G$  MODULUS OF SHEAR DEFORMATION  
 $k_s$  MODULUS OF SUBGRADE REACTION  
 $m, n$  STABILITY COEFFICIENTS  
 $A, B$  PORE PRESSURE COEFFICIENTS  
**NOTE:** EFFECTIVE STRESS PARAMETERS ARE DENOTED BY USE OF APOSTROPHE ABOVE THE SYMBOL, THUS:  
 $\phi'$  = EFFECTIVE ANGLE OF SHEARING RESISTANCE;  
 $\sigma'$  = 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  
 $\eta$  COEFFICIENT OF VISCOSITY  
 $k$  COEFFICIENT OF HYDRAULIC CONDUCTIVITY  
 $k_h$   $k$  IN HORIZONTAL DIRECTION  
 $k_v$   $k$  IN VERTICAL DIRECTION  
 $\alpha_v$  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)

Site 20

Corkett Creek

0 - 3 ft Top Soil

3 - 23 ft Silty Sand

23 - 31.5 Clay Silt (glacial Till)

① 12" granular 'A' pad



ENGINEERING MATERIALS OFFICE  
SOIL MECHANICS SECTION

WP 38-77-01 DIST 6  
HWY 401 STR SITE 22-171

South Service Road  
Over East Corbett Creek

DISTRIBUTION

G.C.E. Burkhardt (3)  
R.D. Gunter  
M.R. Ernesaks  
D.E. Thrasher (2)

C. Grebski  
G.A. Wrong  
B.J. Giroux  
R.S. Pillar

R. Hore

R. Fitzgibbon )  
J. Anderson ) cover only  
G. Sloan )

Files ✓

SAMPLE DISPOSITION NOTICE		
TYPE	DISCARD AFTER	RECOMM. BY
JARS	78 08 15	MD
TUBES	-	-
ROCK COKES	-	-

*Contd 82 72*

# FOUNDATION INVESTIGATION REPORT

For

South Service Road  
Over East Corbett Creek  
Hwy. 401, District 6, Toronto  
W.P. 38-77-01, Site 22-171

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## INTRODUCTION

This report summarizes the results of a foundation investigation carried out for the project at the above mentioned site. Previous work performed by this Section under the same Work Project consisted of an investigation at the crossing of the South Service Road over the Corbett Creek with the report issued on September 8, 1977. The fieldwork for the above mentioned site was carried out on June 21, 1978. Two sampled boreholes, one accompanied by a dynamic cone penetration test, were advanced by means of continuous flight 3½" hollow stem augers to depths ranging from 31.5 feet to 35.5 feet below the existing ground surface.

## SITE DESCRIPTION AND GEOLOGY

The site is situated at the crossing of the proposed South Service Road at the East Corbett Creek, about 2,500 feet east of Thickson Road and 700 feet south of the existing Hwy. 401 centerline. This location is in the eastern boundary of the Town of Whitby, Regional Municipality of Durham.

The East Corbett Creek originates about half a mile north of the crossing and flows into the Corbett Creek about 1 mile south of the crossing. The depth of water, at the time of investigation, varied from 4 to 12 inches. The creek has eroded the surficial deposits to a depth of 3 to 4 feet with steep channel banks and a flat bed of approximately 6 feet in width.

The topography in the immediate area is slightly undulating and generally slopes gently towards the south. The land is presently used for grazing purposes, with neighbouring properties sodded for feed purposes.

Physiographically, the area is situated in the region known as the Iroquois Plain which consists of lowlands that were inundated by the glacial Lake Iroquois in the late Pleistocene period. This plain has a fairly constant pattern characterized by till plains, drumlins and areas of silty lacustrine deposits.

#### SUBSURFACE CONDITIONS

The subsoil encountered at this site can be divided into two deposits; a lacustrine silty sand ranging in depths from 19.0 to 23 feet below ground surface, and an underlying glacial till deposit consisting of clayey silt with sand and trace of gravel explored to a maximum thickness of 16.5 feet.

The boundaries between the various soil types are shown on the attached Record of Borehole Sheets. The locations and elevations of the borings, along with an estimated stratigraphical profile based on the borehole data, is shown on Drawing 3877-01.

The various subsoil types encountered are briefly described in the following paragraphs.

##### Silty Sand

A surficial deposit of silty sand some gravel, trace of clay was found to cover the site. Overlying this deposit was a 1.6 to 3.0' veneer of topsoil. The thickness of the granular deposit ranged from 19.0 feet to 23.0 feet. The 'N' values range from 7 blows/foot to 24 blows/foot, indicating a relative density for this deposit which ranges from loose to compact but in general compact throughout. A plot of grain size distribution is shown in envelope form on Figure 1.

##### Clayey Silt (Glacial Till)

Underlying the silty sand deposit is a competent glacial till deposit consisting of clayey silt with sand and trace of gravel. This deposit was found to be generally unsorted and well graded, but cobbles and boulders were encountered in increasing frequency below a depth of 28 feet. This till deposit was explored for a maximum thickness of 16.5 feet, corresponding to a depth of 35.5 feet below ground surface.

Laboratory testing consisting of Atterberg Limits, moisture contents and grain size analysis performed on representative samples of this deposit gave the following results:

	<u>Range</u>
Natural Moisture Content (W) %	8-13
Plastic Limit (W <sub>p</sub> ) %	10-12
Liquid Limit (W <sub>L</sub> ) %	17.0-21
Plasticity Index (I <sub>p</sub> ) %	6-9

In general, testing indicated the clayey silt matrix of the glacial till is inorganic in nature of low plasticity. The 'N' values from the Standard Penetration Test for this deposit ranged from 18 blows/foot to 149 blows for 6 inches, indicating the glacial till is very stiff to hard in consistency, increasing with depth.

Typical grain size distribution curves obtained from samples of this deposit are plotted on Figure 1.

A summary of the Atterberg Limit Tests are shown on the Plasticity Chart on Figure 2.

#### Groundwater

The water table in the immediate area was found to approximate the East Corbett Creek water level. The groundwater may exhibit considerable seasonal fluctuation as a result of being perched on top of a relatively impermeable till deposit in a shallow free-draining lacustrine deposit.

## DISCUSSION AND RECOMMENDATIONS

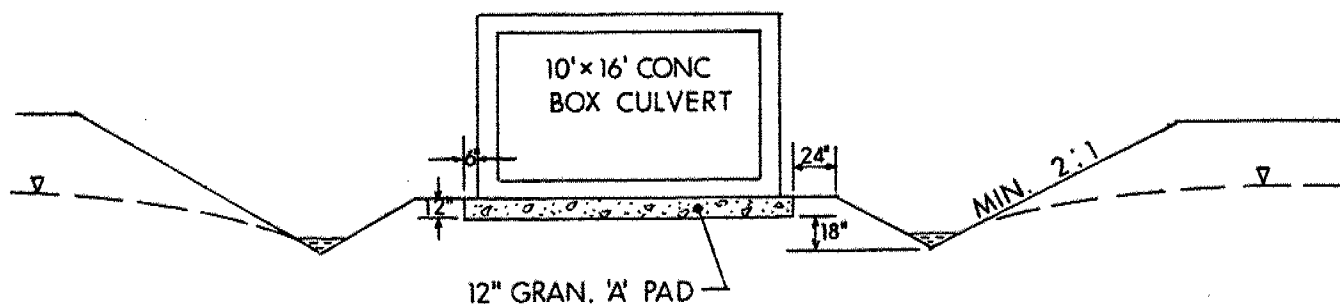
As part of the reconstruction of the Hwy. 401 and Thickson Road interchange, it is proposed to relocate the South Service Road south of the existing alignment. A proposed 10' x 16' concrete box culvert will carry the relocated South Service Road over the East Corbett Creek, some 2,500 feet east of Thickson Road. Fill heights of up to 11 feet will be required at the approaches to the culvert.

In view of the uniform subsoil conditions at this location, recommendations pertaining to the creek crossing are as follows.

### Box Culvert

The concrete box culvert can be supported on a mat foundation founded within the silty sand stratum provided all topsoil material is removed entirely below the base of the culvert foundation. In order to provide a compacted and uniform foundation bedding, a 12 inch thick compacted granular 'A' pad should be placed to 6 inches in excess of the full base width of the culvert. Consideration may be given to articulate the performance of the box culvert below the embankment so as to compensate for differential settlement. Provisions for construction joints to accommodate a 2 inch camber beneath the service road centerline should prove to be sufficient. In order to construct the box culvert in the dry, a temporary earth dyke or stream diversion will be required.

For excavations beneath the water table a positive dewatering system such as the oversize trench excavation illustrated below will be required.



Cross-section of Oversize Trench  
Excavation for Dewatering Purposes

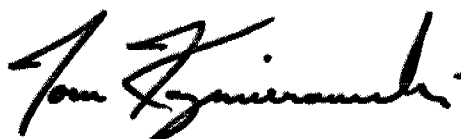
Assuming a rigid box culvert, which allows no movement at the top of the wall, a coefficient of earth pressure at rest,  $K_0$ , of 0.5 may be used to estimate the earth pressure acting against the wall. To estimate the horizontal resistance against sliding between the rough concrete and the granular 'A' pad, a value of 0.6 for the coefficient of friction may be used for design purposes.

#### Alternative Culvert Types

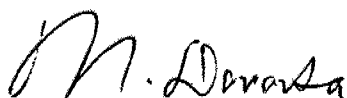
The site is also suitable for the construction of a structural steel plate arch or pipe culvert provided bedding and backfilling operations are carried out as per current M.T.C. practice. Particular attention should be given to the compaction of the bedding material beneath the haunches of the pipe to ensure that the desired degree of compaction is achieved. To allow for flexibility and deflection of the pipe, the granular 'A' pad should be carefully shaped and levelled for the width of the area under the bottom radius of the pipe. Again, a positive dewatering scheme as mentioned previously, will be required for the placement of the granular mat and bedding.

#### Embankments

No stability problems are anticipated for the fills approaching the East Corbett Creek if the slopes are constructed not steeper than 2:1. For protection against embankment erosion, standard seeding/sodding operations should be carried out with limited rip-rap utilization at the creek banks for slope protection as per hydraulical requirements.



T. Kazmierowski  
Project Engineer



M. Devata, P. Eng.  
Supervising Engineer



July, 1978

## APPENDIX



# RECORD OF BOREHOLE No 1

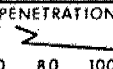
W P 38-77-01 LOCATION Coords. N 15,940,960; E 1,159,448 ORIGINATED BY T.K.  
DIST 6 HWY 401 BOREHOLE TYPE Continuous Flight 3 1/2" Hollow Stem Augers COMPILED BY  
DATUM Geodetic DATE June 21, 1978 CHECKED BY K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
269.3	Ground Surface																GR SA SI CL
0.0	Topsoil																
1.6	Silty Sand Some Gravel Trace Clay		1	SS	11												9 53 30 8
			2	SS	15												15 46 32 7
			3	SS	15												5 52 38 5
			4	SS	13												
	Compact		5	SS	11												22 42 30 6
			6	SS	24												
250.3																	
19.0	Clayey Silt With Sand and Gravel		7	SS	18												5 32 45 18
	(Glacial Till)		8	SS	32												
	Cobbles from 28.0'		9	SS	217												12 30 34 24
	Firm to Hard																
233.8			10	SS	1497	6"											
35.5	End of Borehole																
	* Open hole water level reading taken 4 hours after completion on borehole																



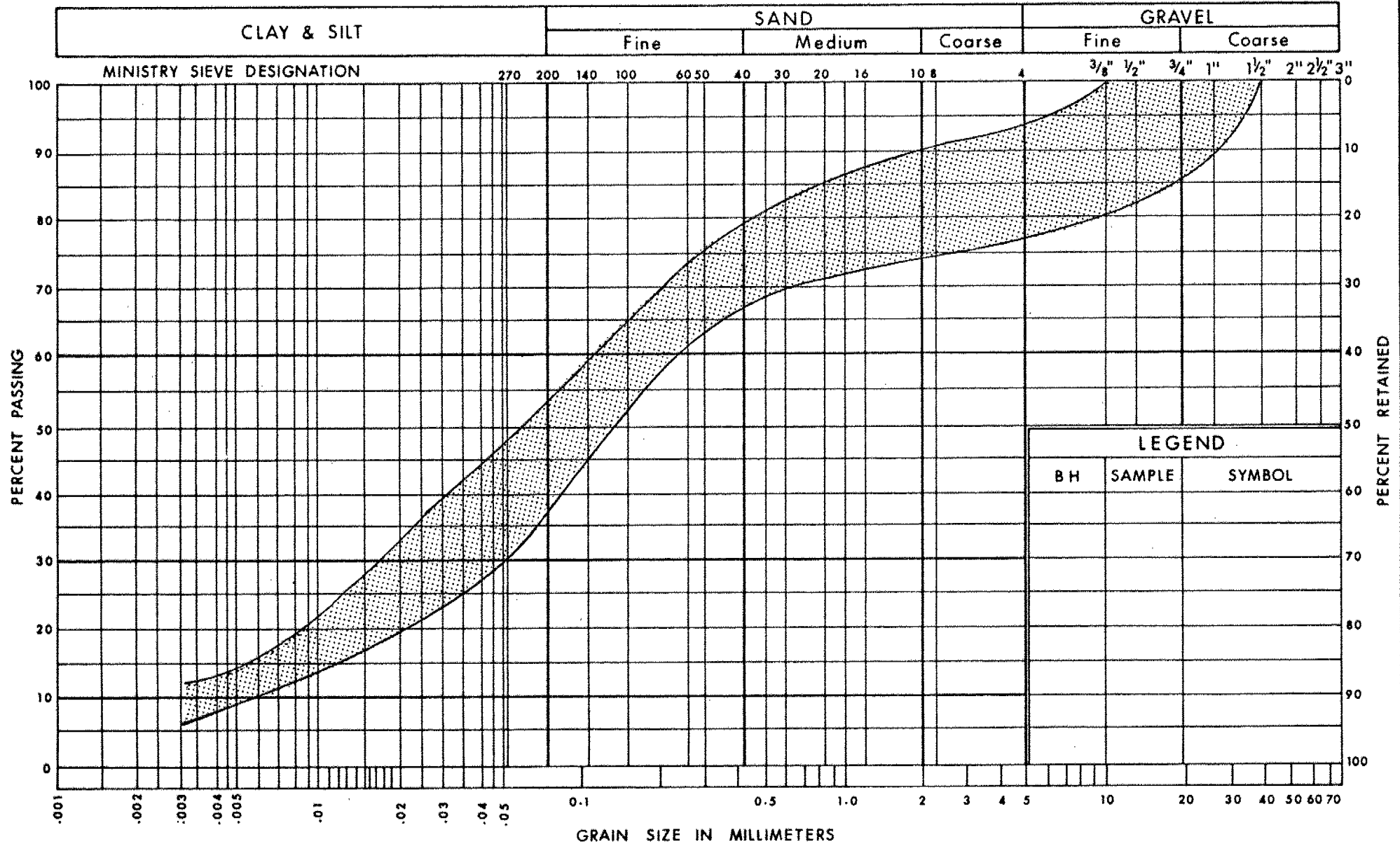
# RECORD OF BOREHOLE No 2

W P 38-77-01 LOCATION Coords. N 15,940,868; E 1,159,486 ORIGINATED BY T.K.  
 DIST 6 HWY 401 BOREHOLE TYPE Continuous Flight 3 1/2" Hollow Stem Augers COMPILED BY   
 DATUM Geodetic DATE June 21, 1978 CHECKED BY K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
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OFFICE REPORT ON SOIL EXPLORATION

# UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario  
ENGINEERING SERVICES BRANCH

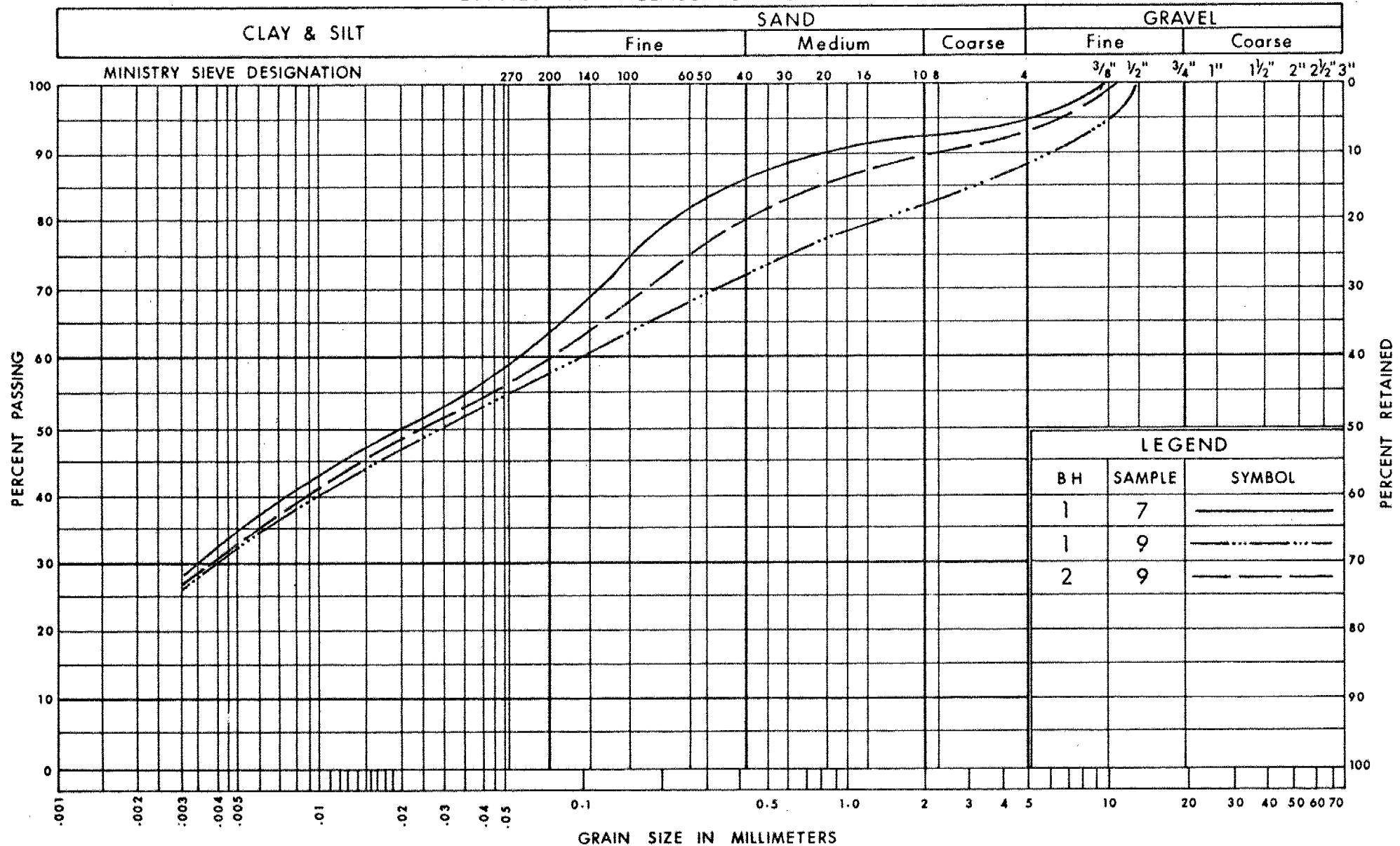
Ministry of  
Transportation and  
Communications

GRAIN SIZE DISTRIBUTION  
SILTY SAND  
SOME GRAVEL TRACE OF CLAY

FIG No 1

W P 38-77-01

## UNIFIED SOIL CLASSIFICATION SYSTEM



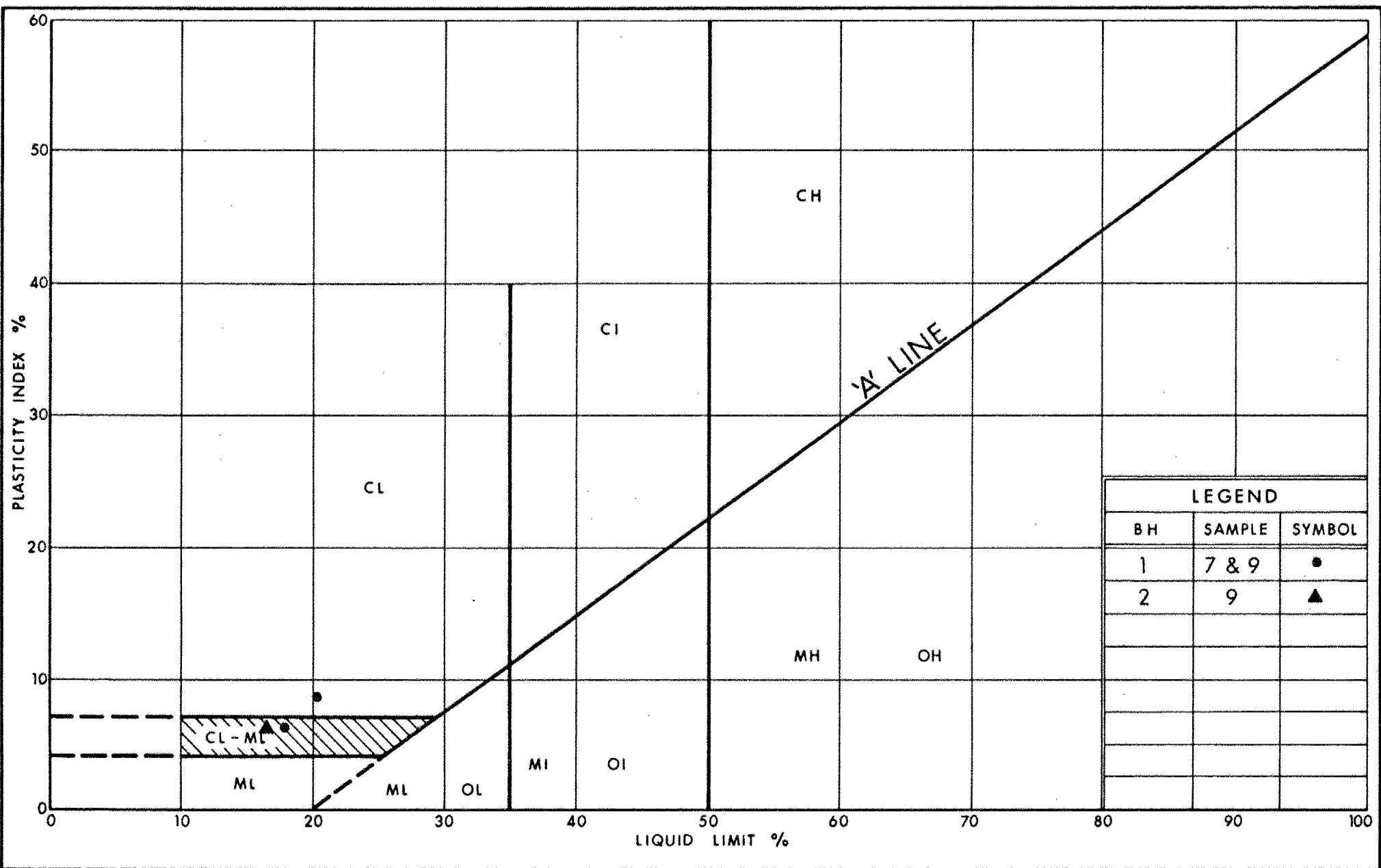
Ontario  
ENGINEERING SERVICES BRANCH

Ministry of  
Transportation and  
Communications

GRAIN SIZE DISTRIBUTION  
CLAYEY SILT  
WITH SAND TRACE OF GRAVEL  
(GLACIAL TILL)

FIG No 2

W P 38-77-01



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 $i$  ANGLE OF INCLINATION OF SURCHARGE  
 $w$  SLOPE ANGLE-BACKFACE OF WALL  
 $\beta$  ANGLE OF SLOPE  
 $N, N_q, N_c$  BEARING CAPACITY FACTORS  
 $D_f$  DEPTH OF FOOTING  
 $B, L$  FOOTING DIMENSIONS

### INDEX PROPERTIES

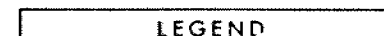
$\gamma$  UNIT WEIGHT OF SOIL (BULK DENSITY)  
 $\gamma_w$  UNIT WEIGHT OF WATER  
 $\gamma_d$  UNIT DRY WEIGHT OF SOIL (DRY DENSITY)  
 $\gamma'$  UNIT WEIGHT OF SUBMERGED SOIL  
 $G_s$  SPECIFIC GRAVITY OF SOLIDS  
 $e$  VOIDS RATIO  
 $e_o$  INITIAL VOIDS RATIO  
 $e_{max}$   $e$  IN LOOSEST STATE  
 $e_{min}$   $e$  IN DENSEST STATE  
 $D_r$  RELATIVE DENSITY =  $\frac{e_{max} - e}{e_{max} - e_{min}}$   
 $n$  POROSITY  
 $w$  WATER CONTENT  
 $w_L$  LIQUID LIMIT  
 $w_p$  PLASTIC LIMIT  
 $w_s$  SHRINKAGE LIMIT  
 $I_p$  PLASTICITY INDEX =  $w_L - w_p$   
 $I_L$  LIQUIDITY INDEX =  $\frac{w - w_p}{I_p}$   
 $I_c$  CONSISTENCY INDEX =  $\frac{w_L - w}{I_p}$   
 $A_c$  ACTIVITY =  $\frac{I_p \text{ of soil}}{2.4 \mu m \text{ Soil Fraction}}$   
 $Om$  ORGANIC MATTER CONTENT  
 $S_r$  DEGREE OF SATURATION  
 $S$  SENSITIVITY =  $\frac{S_u \text{ (undisturbed)}}{S_u \text{ (remoulded)}}$

### STRENGTH PARAMETERS

$\phi$  ANGLE OF SHEARING RESISTANCE  
 $\tau_f$  PEAK SHEAR STRENGTH  
 $\tau_R$  RESIDUAL SHEAR STRENGTH  
 $c$  COHESION INTERCEPT  
 $\sigma_1, \sigma_2, \sigma_3$  NORMAL PRINCIPAL STRESSES  
 $u$  PORE WATER PRESSURE  
 $u_e$  EXCESS  $u$   
 $r_u$  PORE PRESSURE RATIO  
 $q_u$  UNCONFINED COMPRESSIVE STRENGTH  
 $s_u$  UNDRAINED SHEAR STRENGTH  
 $\epsilon$  LINEAR STRAIN  
 $\gamma$  SHEAR STRAIN  
 $\nu$  POISSON'S RATIO  
 $E$  MODULUS OF ELASTICITY  
 $G$  MODULUS OF SHEAR DEFORMATION  
 $k_s$  MODULUS OF SUBGRADE REACTION  
 $m, n$  STABILITY COEFFICIENTS  
 $A, B$  PORE PRESSURE COEFFICIENTS  
  
NOTE: EFFECTIVE STRESS PARAMETERS ARE DENOTED BY USE OF APOSTROPHE ABOVE THE SYMBOL, THUS:  
 $\phi'$  = EFFECTIVE ANGLE OF SHEARING RESISTANCE;  
 $\sigma'$  = 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  
 $\eta$  COEFFICIENT OF VISCOSITY  
 $k$  COEFFICIENT OF HYDRAULIC CONDUCTIVITY  
 $k_h$   $k$  IN HORIZONTAL DIRECTION  
 $k_v$   $k$  IN VERTICAL DIRECTION  
 $m_v$  COEFFICIENT OF VOLUME CHANGE  
 $c_v$  COEFFICIENT OF CONSOLIDATION  
 $C_c$  COMPRESSION INDEX  
 $C_r$  RECOMPRESSION INDEX  
 $d$  DRAINAGE PATH DISTANCE  
 $T_v$  TIME FACTOR  
 $U$  DEGREE OF CONSOLIDATION  
 $O_r$  OVERCONSOLIDATION RATIO (OCR)



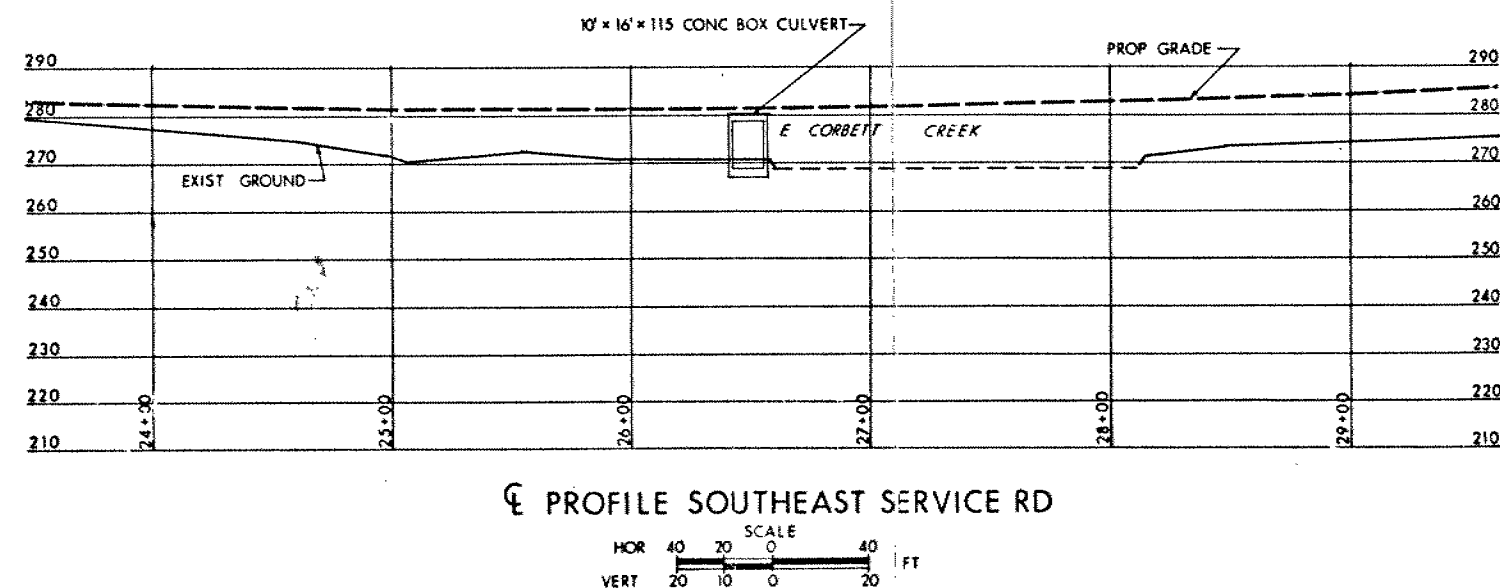
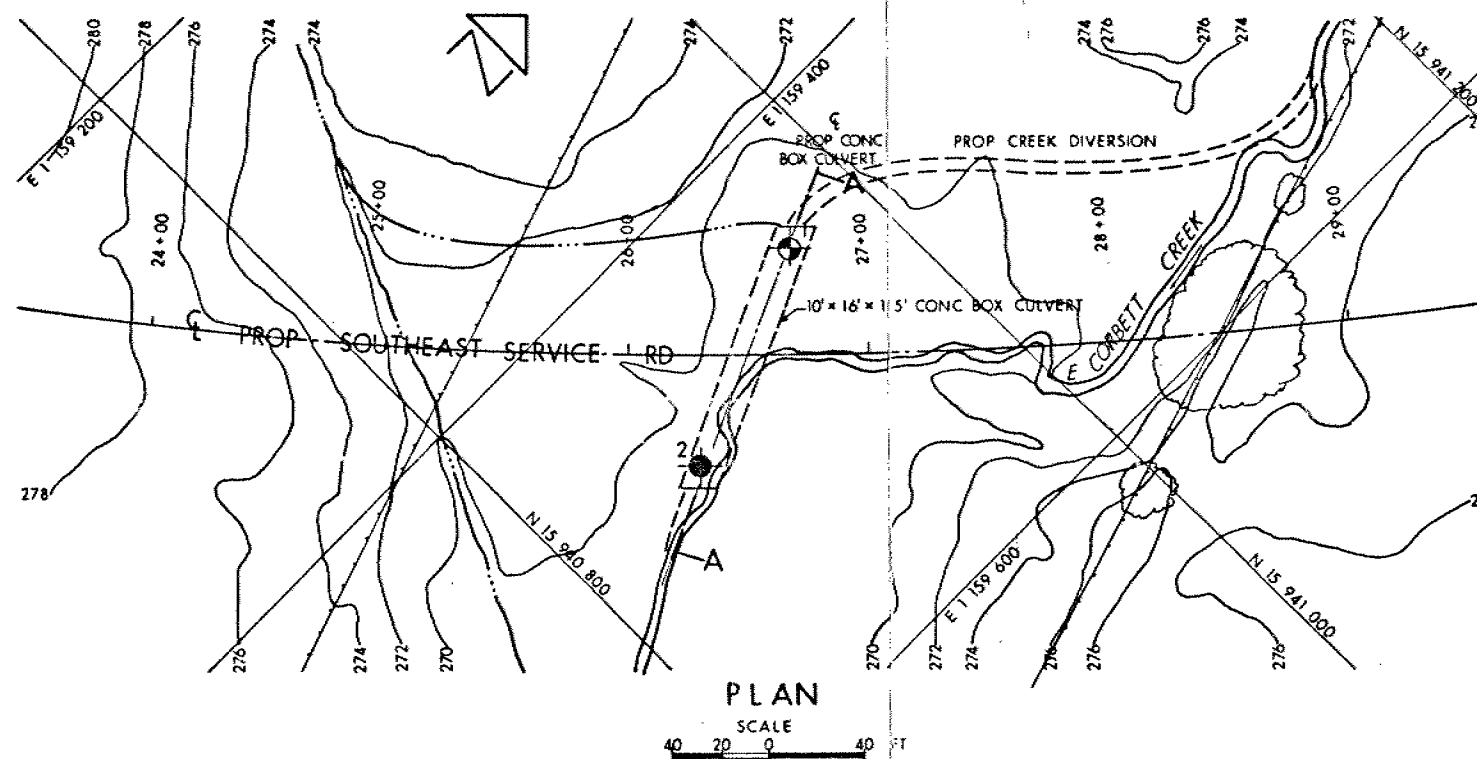
- | No | ELEVATION | CO-ORDINATES |           |
|----|-----------|--------------|-----------|
|    |           | NORTH        | EAST      |
| 1  | 269.3     | 15 940 960   | 1 159 448 |
| 2  | 269.6     | 15 940 868   | 1 159 486 |

**-NOTE-**

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

GEOCRE5 No 30M15-46

HWY No. 401 (S-E SERVICE RD) DIST 6  
 PLANT K CHECKED ☒ DATE 78 07 05 SITE 22-171  
 DRAWING CHECKED ☒ DATE 78 07 05 DWT 387701



cont 82-72



Ministry of  
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Communications

# foundation investigation and design report

ENGINEERING MATERIALS OFFICE  
SOIL MECHANICS SECTION

WP 38-77-01

DIST 6

HWY 401

STR SITE 22-171

South Service Road  
over Corbett Creek

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cont. 82-72



# FOUNDATION INVESTIGATION REPORT

For

South Service Road  
over Corbett Creek  
Hwy. 401 District 6, Toronto  
W.P. 38-77-01, Site No. 22-171

---

## INTRODUCTION

This report contains the results of a foundation investigation carried out at the site of the above mentioned project. The fieldwork was carried out during the period of June 29th. to July 5th., 1977. It consisted of three sampled boreholes, two accompanied by a dynamic cone penetration test, advanced by means of 3¼" hollow stem flight augers to depths ranging from 21 feet to 51 feet below the existing ground surface.

## SITE DESCRIPTION AND GEOLOGY

The site is located at the crossing of the proposed South Service Rd. of Hwy. 401 at Corbett Creek, about 350 ft. west of Thicksen Road in the Town of Whitby, Regional Municipality of Durham. Corbett Creek originates about one mile north of the site, flowing south about 1½ miles into Lake Ontario. At the time of the field investigation, the depth of the water in the Creek was about 2 to 3 inches. The creek bed is approximately 10 feet wide and 2 to 3 feet below the average ground surface with almost vertical banks.

Hilly terrain is prevalent throughout the surrounding area, whereas in the immediate vicinity of the site, the terrain is sloping gently towards the creek. Land to the east of the creek is utilized for pasture and an apple orchard is located immediately west of the creek.

The area is situated in the region physiographically known as the Iroquois Plain. This lowland bordering Lake Ontario was inundated in the late Pleistocene period by the glacial Lake Iroquois. It is characterized by some till plains, drumlins and silty lacustrine deposits.

## SUBSURFACE CONDITIONS

### General

Except for a 4 foot thick layer of topsoil found immediately below the ground surface east of the creek, generally uniform conditions prevail over the area. The site is underlain by a 16 to 24 foot thick deposit of soft to firm clayey silt with occasional layers or seams of sandy silt and clay, which overlies a glacial till. This compact to very dense glacial till (a heterogeneous mixture of silt, sand and some gravel with trace of clay) is at least 25 feet in thickness.

Detailed description of the various soil strata encountered is shown in the Record of Borehole Sheets. The stratigraphical section shown on Drawing No. 387701-A is inferred from the borehole data.

Following is the detailed description of the soil types encountered:

### Topsoil

East of the creek, a 4 foot layer of topsoil was found just beneath the ground surface. Based on the laboratory results, the organic content of this layer was found to be 9 percent by weight. The 'N' values as per the Standard Penetration test indicate the topsoil is soft.

### Clayey Silt

This cohesive deposit of clayey silt was encountered just below the topsoil to the east and immediately below the ground surface to the west of the creek. This stratum is composed of clayey silt with occasional layers or seams of sandy silt and clay. It extends to a depth ranging from 16 to 24 feet below the ground surface.

The results of laboratory and field tests performed on the representative samples from this area gave the following results:

<u>Identity Indices</u>	<u>Range</u>	<u>Average</u>
Natural Moisture Content (W ) %	11-31	21
Liquid Limit (W <sub>L</sub> ) %	20-35	24

<u>Identity Indices</u>		<u>Range</u>	<u>Average</u>
Plastic Limit	( $W_p$ ) %	10-21	13
Plasticity Index	( $I_p$ ) %	7-14	11
Liquidity Index	( $I_L$ ) %	0-1.8	0.9
Bulk Density	( $\gamma$ ) psf	109-136	123
<u>Undrained Shear Strength (cu) psf</u>		<u>Range</u>	<u>Sensitivity</u>
Field Vane tests		320-( $>2400$ )	2-6
Laboratory Vane tests		1560-6150	3-8
<u>Consolidation Characteristics (One Test)</u>			
Initial Void Ratio ( $e_o$ )			0.66
Compression Index ( $C_c$ )			0.17
Degree of Preconsolidation $P'_c - P'_o$ (PSF)			10,000

The Atterberg Limit tests summarized above, are also plotted on the plasticity chart Fig. 1.

These results indicate that the clayey silt stratum is of low to medium plasticity. The liquid limit is slightly greater than the natural moisture content and both generally decrease with depth. However, within the clayey silt stratum at a depth of about 12 feet, the Atterberg Limits indicate the presence of a layer of silty clay to clay of medium to high plasticity. Based on the average liquidity index which is slightly less than one, the clayey silt deposit is inferred to be generally insensitive to remoulding. This is confirmed by the sensitivities as measured by the field vane tests.

The undrained shear strength as measured by the field vane tests, decreases with depth from being greater than 2400 psf to 320 psf. Undrained shear strength values obtained in the laboratory differ from those obtained in the field. This can be attributed to sample disturbance caused by field and laboratory handling and subsequent testing of the samples. The consistency of the clayey silt stratum decreases with depth from stiff to soft.

### Glacial Till

A glacial till deposit was found immediately below the cohesive clayey

silt stratum. The thickness of this strata was not fully explored but extends to a depth of approximately 25 feet. The glacial till is composed of a heterogeneous mixture of silt, sand, gravel and trace of clay. The Standard Penetration Test 'N' values range from 13 blows per foot to 126 blows per foot, indicating the glacial till deposit has a relative density ranging from compact to very dense. The grain size distribution curve and the plasticity chart are shown in Figures 2 and 3 respectively.

#### GROUNDWATER CONDITIONS

The groundwater level was observed during the course of the investigation. Artesian conditions were encountered in two of the borings, consequently the groundwater level was observed in one borehole only. The water level was found to be about 1 foot below the existing ground surface which corresponds to elevation 270. The water in the creek at the time of the field investigation was found to be at elevation 269.

Artesian conditions were observed in the borehole east of the creek only upon completion of the borehole. About 24 hours after completing the boring, water was observed flowing from the borehole. The boring remained open to a depth of 35 feet.

Two GEONOR piezometers were installed west of the creek and approximately 100 feet north of the proposed centreline of the South Service Road. One piezometer was located in the clayey silt stratum and one was located in the glacial till stratum. The artesian head from both these piezometers was found to be about 4 feet above existing ground surface. The piezometer data is shown on the Record of Borehole Sheet #3.

## DISCUSSION AND RECOMMENDATIONS

It is proposed to relocate the South Service Road of Hwy. 401 at Thickson Road. The proposed crossing of the relocated South Service Road at Corbett Creek, some 350 feet west of Thickson Road, is to be accomplished by means of 10' x 16' concrete box culvert. Fill heights of up to 20 feet would be required in this area. The presence of the soft clayey silt stratum is the governing factor from a foundation point of view, since it will be necessary to ensure that this stratum is not overstressed by the embankment loading. The relevance of this is discussed in the following subsections.

### Stability Considerations

Analysis in terms of total stress have been carried out to determine the stability of fills immediately after construction. In this method of analysis, stability is governed by undrained shear strength properties of the foundation and fill materials. The following data and values were used in carrying out the stability analysis:

#### Fill Material

	<u>(pcf)</u>	<u><math>\phi^0</math></u>	<u>Cu (psf)</u>
Granular material	140 <sup>0</sup>	35 <sup>0</sup>	0

#### Subsoil Foundation Material

<u>Elevation (ft.)</u>	<u>(pcf)</u>	<u>(pcf)</u>	<u><math>\phi^0</math></u>	<u>Cu(psf)</u>
272-261	122	60	0	1700
261-254	122	60	0	600
254-243	122	60	0	400
Below 243	132	70	35	0

Based on the stability analysis fills up to 20 feet would be stable with side slopes of 2 horizontal to 1 vertical. If fill heights exceed 20 feet counterbalancing berms would be required to ensure stability.

For example, fill heights of 24 feet with side slopes of 2:1 would require 25 foot long counterbalancing berms at mid-height on both sides of the embankment to prevent deep seated rotational failure.

### Settlement of Embankment

The weight of the embankment will induce stresses within the soil strata, resulting in the settlement of the compressible clayey silt stratum.

The distribution of these induced stresses was computed using the 'Purdue Method'. For the settlement determination, the soil parameters employed were based on one laboratory consolidation test.

Settlement analysis indicates that the maximum settlement due to a 20 foot embankment will be about 4 inches. Of this, approximately 90 percent will occur within the first 2 months upon completion of the fill.

### Box Culvert

The concrete box culvert can be supported on a mat foundation founded within the stratum of clayey silt. The upper 2 to 3 feet of this stratum contain a trace of organic material. This upper organic zone and the top-soil should be removed entirely below the base of the culvert foundation. A 1 foot thick compacted granular 'A' pad should be placed to the full base width of the embankment for bedding purposes. In order to articulate the performance of the box culvert below the embankment, provisions should be made for construction joints to accommodate differential settlements and the culvert should be provided with a 3 inch camber beneath the highway centerline. A coefficient of subgrade reaction of 100 tsf/ft. may be used for design purposes. In order to construct the box culvert in the dry, a temporary earth dyke of stream diversion will be required.

To estimate the earth pressure on the box culvert a coefficient of active earth pressure,  $K_o$ , of 0.5 may be used provided no movement at the top of the wall is allowed. To estimate the horizontal resistance to sliding between the rough concrete and the granular 'A' pad a coefficient of friction of 0.6 may be used for design purposes.

### MISCELLANEOUS

The fieldwork for this investigation was supervised by Mr. J. White, Student Engineer, using equipment rented from Site Investigation Services

Ltd., Peterborough.

This report was written by Mr. M. MacLean, Project Engineer, with the assistance of Miss. Y. Jamani, Student Engineer. Mr. B. Ly, Senior Engineer reviewed this report.



*M MacLean*

M. MacLean, P. Eng.  
Project Engineer

*B. Ly*

B. Ly, P. Eng.  
Senior Engineer

BL/MM/bp  
September/77

## APPENDIX



# RECORD OF BOREHOLE No 1

W P 38-77-01 LOCATION Sta 96+36 110' Rt South Service Road Relocation ORIGINATED BY J.W.  
 DIST 6 HWY 401 S. Service Rd. BOREHOLE TYPE Hollow stem augers and Dynamic cone test COMPILED BY Y.J.  
 DATUM Geodetic DATE June 30, 1977 CHECKED BY B.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	400 800 1200 1600 2000					
271.1	Ground Surface													
0.0	Tr. of org. Clayey silt with occasional layers or seams of sandy silt and clay Stiff to Firm		1	SS	4		270						126	e <sub>0</sub> =0.66 C <sub>c</sub> =0.17
			2	TW	PH		260							
255.1			3	TW	PH								136	
16.0	Glacial Till Het. mixture of silt, sand, some gravel, trace of clay  Dense to Very Dense		4	SS	35		250							23 38 31 8
			5	SS	42									35 32 28 5
			6	SS	32		240							
			7	SS	70									
			8	SS	63									16 39 31 14
230.1			9	SS	126		230							
41.0	End of Borehole													

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 2

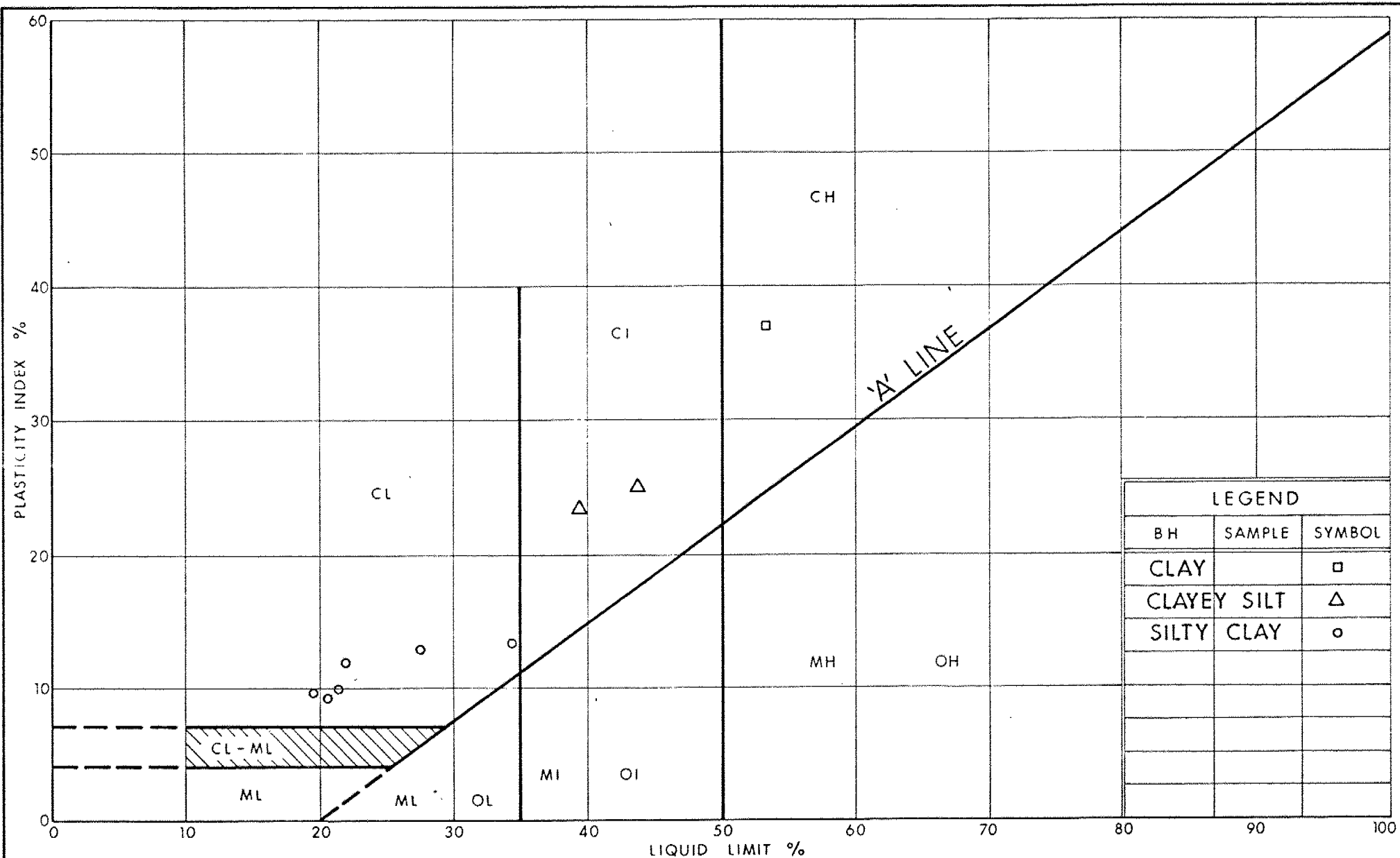
W P 38-77-01 LOCATION Sta. 96+56 15' Rt South Service Road Relocation ORIGINATED BY J.W.  
 DIST 6 HWY 401 S. Service Rd. BOREHOLE TYPE Hollow Stem augers COMPILED BY Y.J.  
 DATUM Geodetic DATE June 29, 1977 CHECKED BY B.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
271.8	Ground Level																
0.0	Topsoil		1	SS	6		270										4 19 57 20 Org. 8.9%
267.8	Soft		2	SS	11												
4.0	Tr. of org.		3	SS	7												
	Clayey silt with occasional layers or seams of sandy silt and clay		4	TW	PH		260									130	
	Stiff		5	TW	PH											109	
	Firm		6	TW	PM												1 10 60 29
			7	TW	PM		250										
	Soft		8	TW	PM											129	13 16 46 25
243.8																	
28.0	Glacial Till		9	SS	13		240										14 39 32 15
	compact Het. mixture of silt, sand, some gravel and trace of clay		10	SS	28												4 64 23 9
	Dense to Very Dense		11	SS	35		230										34 30 27 9
			12	SS	119												
220.9			13	SS	115		220										12 35 36 17
50.9	End of Borehole																
	<p>Note Artesian conditions observed only upon completion of borehole. Borehole was open to depth of 35 feet.</p>																

# RECORD OF BOREHOLE No 3

W P 38-77-01 LOCATION Sta. 95+74 100' Lt South Service Road Relocation ORIGINATED BY J.W.  
 DIST 6 HWY 401 S. Service Rd. BOREHOLE TYPE Hollow Stem augers and Dynamic Cone Test COMPILED BY Y.J.  
 DATUM Geodetic DATE July 5, 1977 CHECKED BY B.L.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
271.9	Ground Level																
0.0	Tr. of org.						270										
	Clayey silt with occ- assional layers or seams of silty sand and clay		1	SS	8											109	
	Firm		2	TW	PH		260									120	22 48 20 10
252.9			3	TW	PM	P2											
19.0	Glacial Till Very																
250.6	Dense		4	SS	54	P1	250										
21.3	End of Borehole																

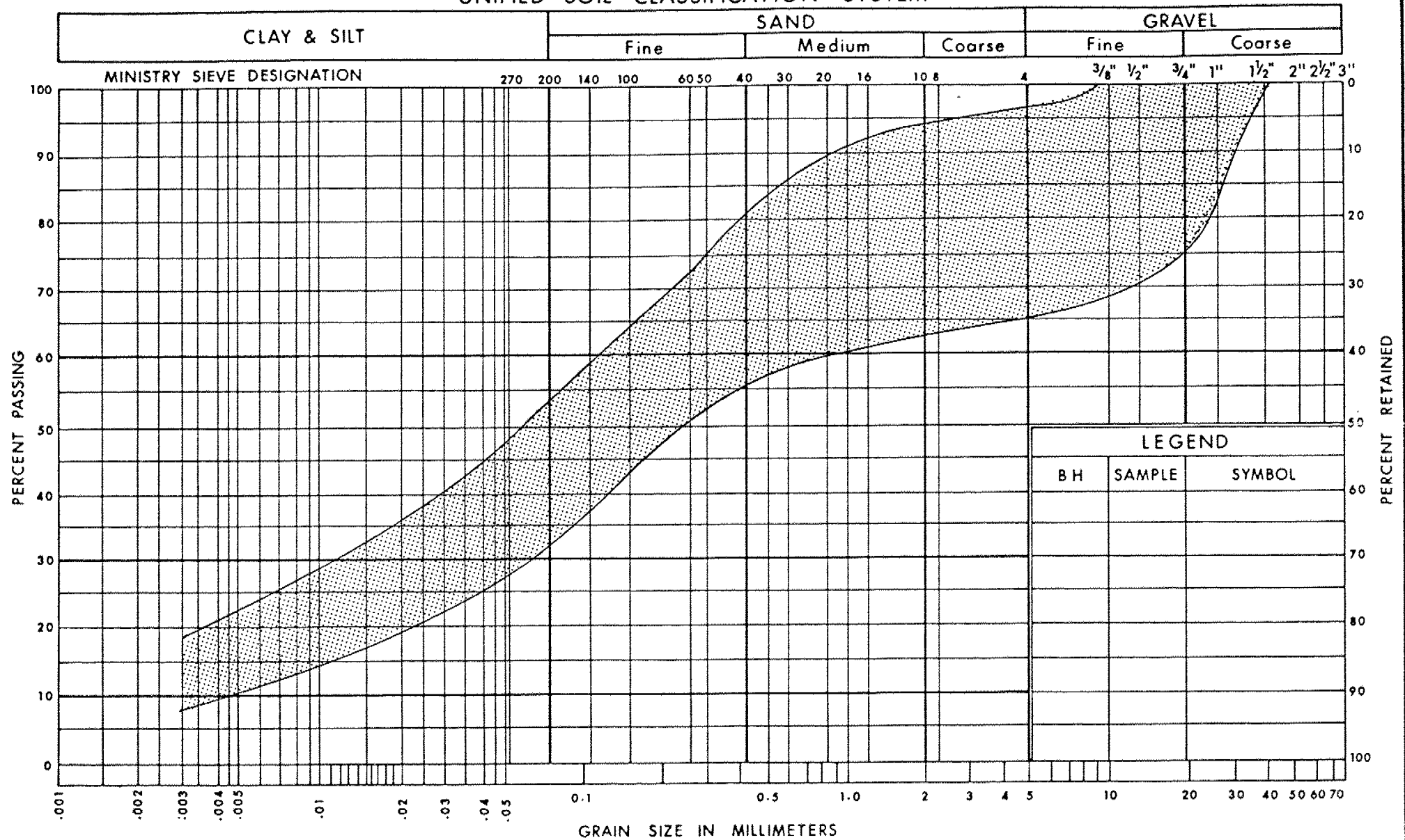


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PLASTICITY CHART  
CLAYEY SILT  
WITH OCCASSIONAL LAYERS OR SEAMS OF SILTY SAND & CLAY

FIG No 1  
W P 38-77-01

# UNIFIED SOIL CLASSIFICATION SYSTEM

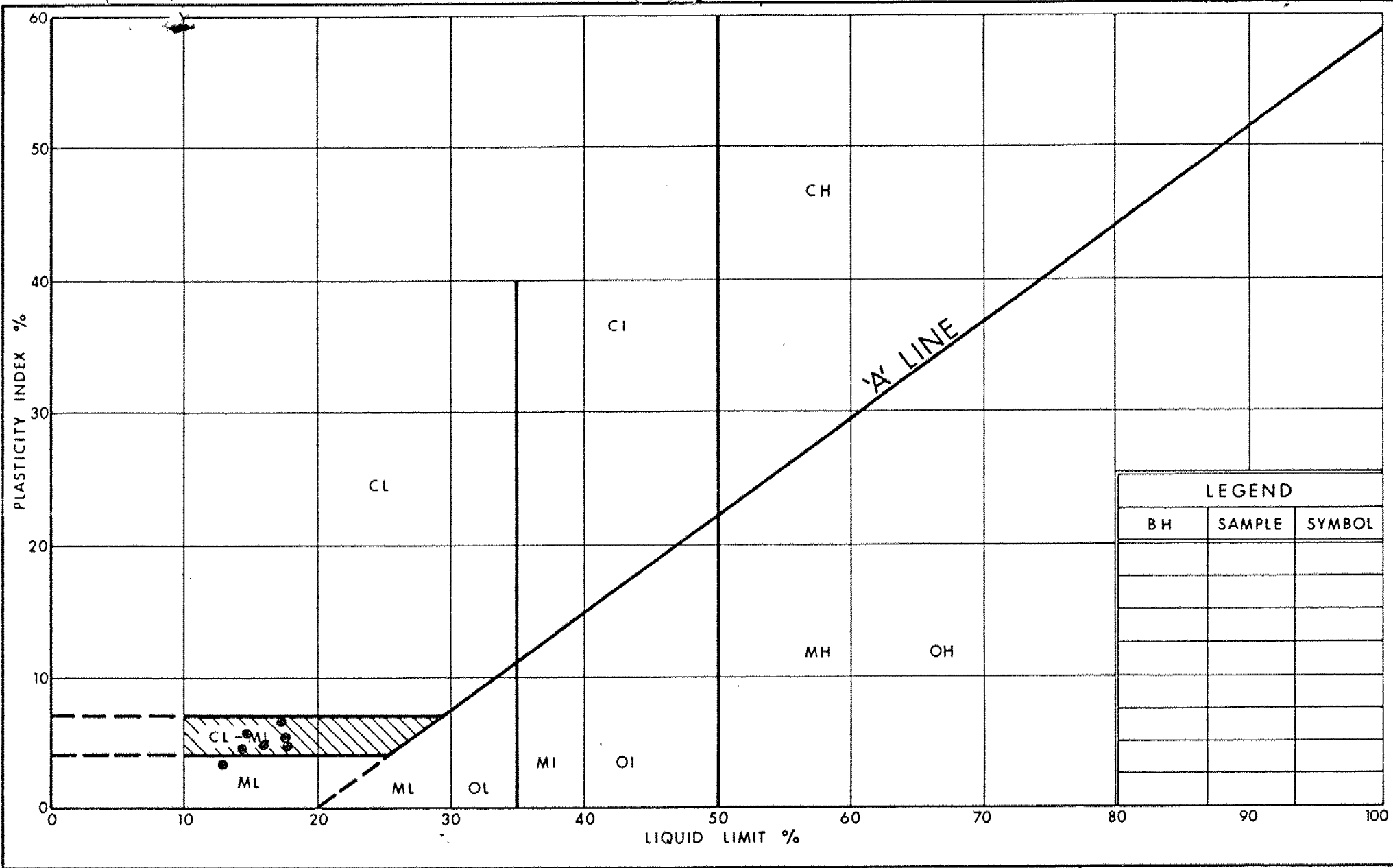
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GRAIN SIZE DISTRIBUTION  
GLACIAL TILL  
HET MIXTURE OF CLAYEY SILT SAND & GRAVEL

FIG No 2

W P 38-77-01



LEGEND		
BH	SAMPLE	SYMBOL

# 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:

$S_u$ (FSF)	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

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

### INDEX PROPERTIES

$\gamma$  UNIT WEIGHT OF SOIL (BULK DENSITY)  
 $\gamma_w$  UNIT WEIGHT OF WATER  
 $\gamma_d$  UNIT DRY WEIGHT OF SOIL (DRY DENSITY)  
 $\gamma'$  UNIT WEIGHT OF SUBMERGED SOIL  
 $G_s$  SPECIFIC GRAVITY OF SOLIDS  
 $e$  VOIDS RATIO  
 $e_o$  INITIAL VOIDS RATIO  
 $e_{max}$   $e$  IN LOOSEST STATE  
 $e_{min}$   $e$  IN DENSEST STATE  
 $D_r$  RELATIVE DENSITY =  $\frac{e_{max} - e}{e_{max} - e_{min}}$   
 $n$  POROSITY  
 $w$  WATER CONTENT  
 $w_L$  LIQUID LIMIT  
 $w_P$  PLASTIC LIMIT  
 $w_S$  SHRINKAGE LIMIT  
 $I_P$  PLASTICITY INDEX =  $w_L - w_P$   
 $I_L$  LIQUIDITY INDEX =  $\frac{w - w_P}{I_P}$   
 $I_c$  CONSISTENCY INDEX =  $\frac{w_L - w}{I_P}$   
 $A_c$  ACTIVITY =  $\frac{I_P \text{ of soil}}{I_P \text{ of } 2\mu m \text{ Soil Fraction}}$   
 $Om$  ORGANIC MATTER CONTENT  
 $S_r$  DEGREE OF SATURATION  
 $S$  SENSITIVITY =  $\frac{S_u \text{ (undisturbed)}}{S_u \text{ (remoulded)}}$

### STRENGTH PARAMETERS

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

### HYDRAULIC TERMS

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

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

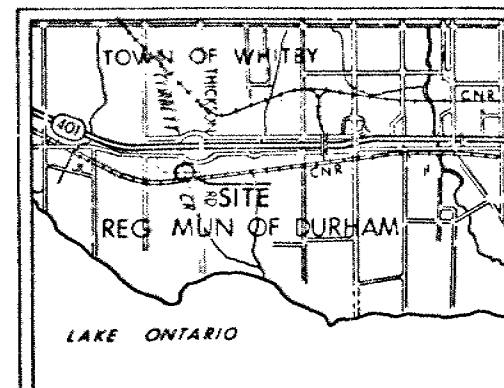
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WP No 38-77-01



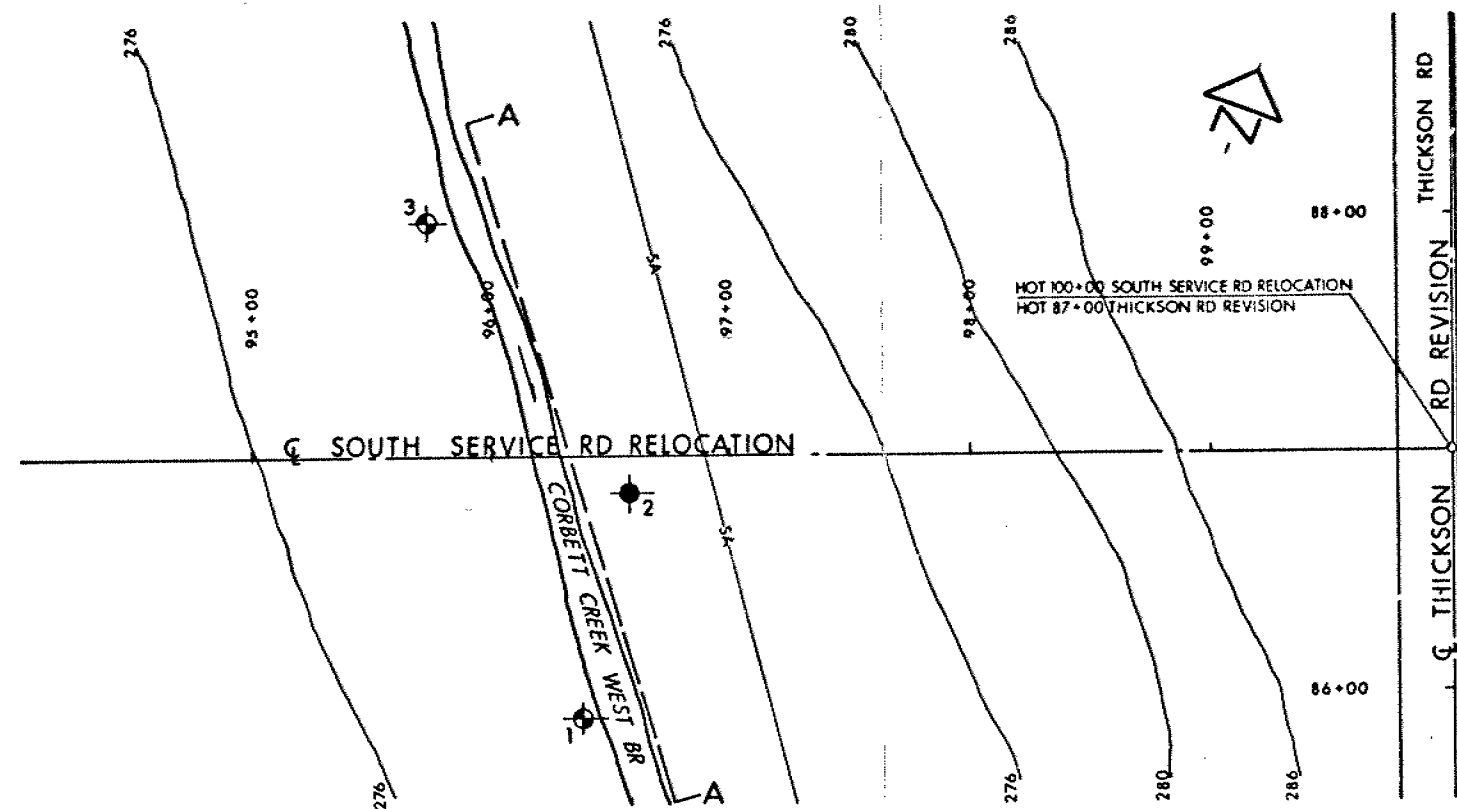
SOUTH SERVICE RD RELOCATION

SHEET

BORE HOLE LOCATIONS & SOIL STRATA

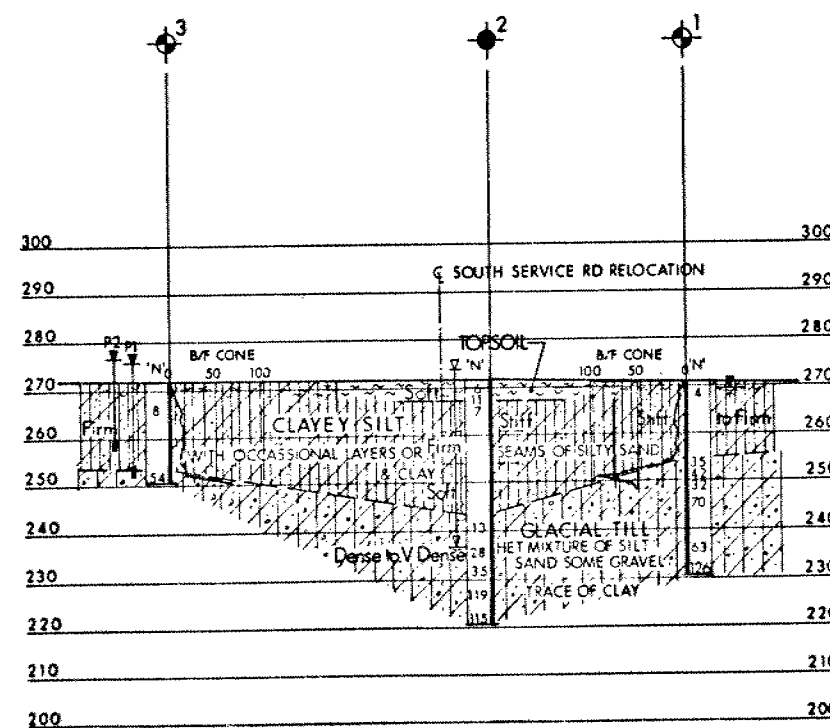


KEY PLAN  
0 50 100 M



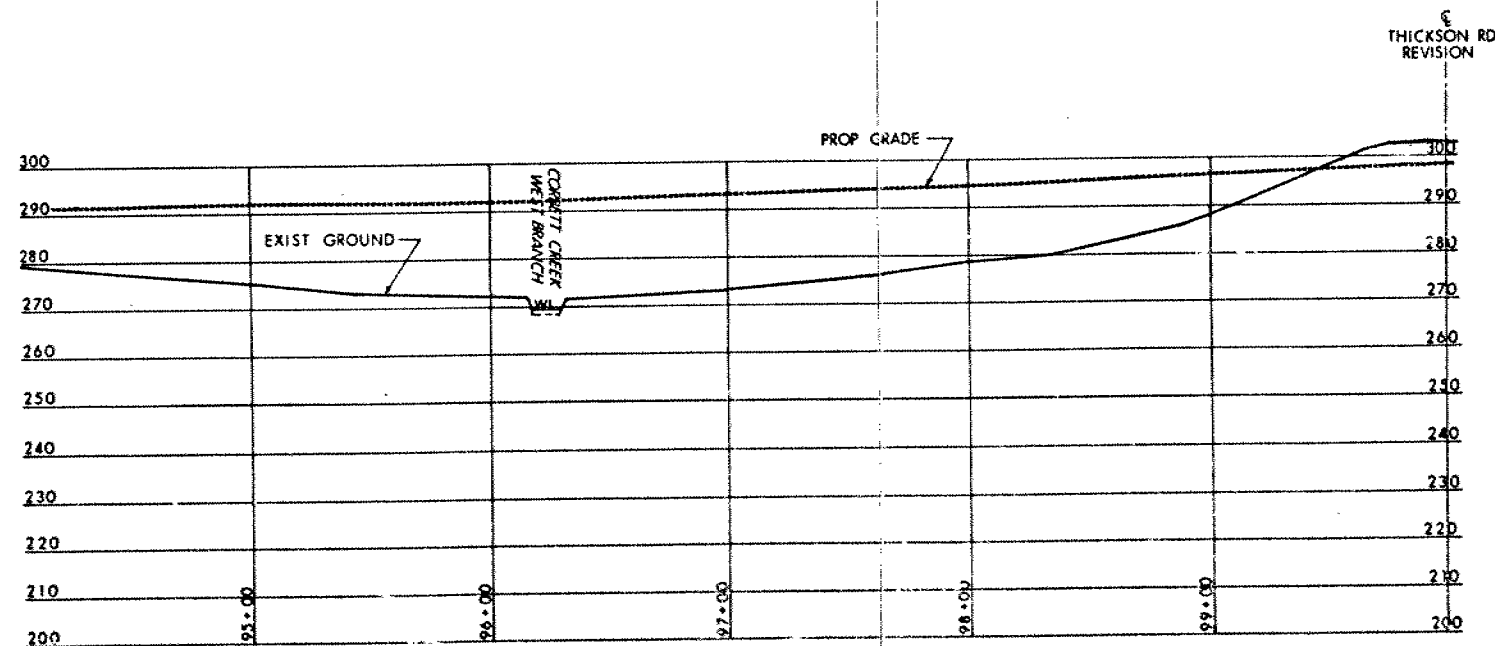
PLAN

SCALE  
40 20 0 20 40 FT



SECTION A-A

SCALE  
HOR 40 20 0 20 40 FT  
VERT 20 10 0 10 20 FT



PROFILE

SCALE  
HOR 40 20 0 20 40 FT  
VERT 20 10 0 10 20 FT

# 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 JUNE 1977
- ⊕ PIEZOMETERS
- ⊕ HEAD ARTESIAN CONDITION ENCOUNTERED

No	ELEVATION	STATION	OFFSET
1	271.1	96+36	110' RT
2	271.8	96+56	15' RT
3	271.9	95+74	150' LT

## 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. 401 THICKSON RD. S. SERVICE RD. DIST. 6  
 SCALE 1" = 40' DATE 16 AUG 1977 SITE 22-171  
 DRAWN BY J. CHECKED BY M. P. MICHIELS  
 387701-A





Ministry of  
Transportation and  
Communications

# foundation investigation and design report

ENGINEERING MATERIALS OFFICE  
SOIL MECHANICS SECTION

WP 38-77-01

DIST 6

HWY 401

STR SITE 22-171

Thickson Road Underpass

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SAMPLE DISPOSITION NOTICE		
TYPE	DISCARD AFTER	RECORDED BY
JARS	78 04 20	M.A.
TUBES	-	-
ROCK CORES	-	-

(cont'd, 38-77-012)

## FOUNDATION INVESTIGATION REPORT

For

Thickson Road Underpass  
3.0 Miles West of Oshawa  
W.P. 38-77-01, Site 22-171  
Hwy. 401, District 6, Toronto

### INTRODUCTION

This report contains the result of a foundation investigation carried out at the site of the above mentioned project during the period of February 14 to 16, 1978.

The fieldwork consisted of six sampled boreholes, each accompanied by a dynamic cone penetration test advanced by means of a continuous flight auger machine equipped with 3 1/4 inch I.D. hollow stem and solid stem augers.

The boreholes ranged in depth from 30 to 46 feet below the ground surface.

### SITE DESCRIPTION AND GEOLOGY

The site is located about 3.0 miles west of the City of Oshawa in the Regional Municipality of Durham.

The area is located in the physiographical region known as Iroquois Plain. In this area the subsoil is a mosaic of till plains, drumlins and areas of silty lacustrine deposits.

### SUBSURFACE CONDITIONS

Subsurface conditions at the site were found to be generally uniform. The original ground, under a 1 ft. layer of topsoil, is a glacial till, composed of a hard heterogeneous mixture of clayey silt, sand and gravel changing with depth to a very dense heterogeneous mixture of silt, sand and gravel.

The lower boundary of the glacial till stratum was not proven at any of the boring locations but was explored to a maximum depth of 31.5 feet below the existing ground surface. The existing Thickson Road embankment is composed of fill material

which is borrowed parent material composed of cohesive glacial till.

A detailed description of the soil encountered in each borehole is given in the Record of Borehole Sheets. The estimated stratigraphical profile and sections shown on Drawing No.387701-A are based upon this information. From ground level downwards, the subsurface conditions are as follows:

#### Fill Material

Two boreholes (B.H. 1 and 5) were carried out through the embankment of the existing Thickson Road at the north and south side of the site. The thickness of the fill material was found to be about 15 feet. The fill material is comprised of a cohesive glacial till (heterogeneous mixture of clayey silt, sand and gravel). The upper 6 to 8 feet of the fill material contains traces of organics.

Standard Penetration Tests gave "N" values in the range of 5 to 22 blows per foot, indicating that the fill material has a firm to very stiff consistency

Glacial Till: (Heterogeneous Mixture of Clayey Silt, Sand and Gravel Changing to a Heterogeneous Mixture of Silt, Sand and Gravel).

Under a 1 foot thick layer of topsoil or immediately under the fill material is a deposit of glacial till. The deposit is composed of a cohesive heterogeneous mixture of clayey silt, sand and gravel changing with depth to a granular heterogeneous mixture of silt, sand and gravel. The boundaries between the upper slightly cohesive portions and lower noncohesive portions of this deposit are difficult to define exactly.

The physical properties of the upper slightly cohesive glacial till as determined from laboratory testing are summerized below:

		Range	Average
Liquid Limit	(W <sub>L</sub> ) %	12-15	14
Plastic Limit	(W <sub>p</sub> ) %	9-13	11
Plasticity Index	(I <sub>p</sub> ) %	1-5	3
Moisture Content	(W) %	5-9	7

The results of the Atterberg Limit Tests are shown on the Plasticity Chart on Figure 1. These results indicate that the matrix is inorganic and of low plasticity. (CL-ML to ML zone)

The result of grain size distribution testing performed on representative samples from the overall glacial till deposit are shown in an envelope form on Figure 2 of the Appendix.

The Standard Penetration Tests gave "N" values in the range of 31 to over 100 blows per foot, generally increasing with depth. Based on these "N" values the consistency of this slightly cohesive stratum is estimated to be hard, whereas the relative density of the lower noncohesive portion of the glacial till has a dense to very dense relative density, generally in the very dense range.

The lower boundary of this glacial till deposit was not established, but was proven to a maximum thickness of 32 feet.

#### Groundwater

The groundwater level conditions were observed by measuring in the open boreholes during and after the completion of the foundation investigation. The groundwater level was found to vary between elevation 282.0 (B.H. <sup>1</sup>3) and 310.0 (B.H. <sup>4</sup>2) which corresponds to 12 to 45 ft. below the existing ground surface. The groundwater levels are shown on the Record of Boreholes Sheets, as well as on Drawing No. 387701-A.

## DISCUSSIONS AND RECOMMENDATIONS

It is proposed to construct a new six lane two span structure carrying Thickson Road over Highway 401. The new alignment of Thickson Road at this crossing will be some 35 feet east of the existing; whereas the alignment of Hwy 401 will remain approximately the same. Current construction proposals utilize the existing two lane structure for traffic while the eastern portion of the new structure is constructed. Upon completion of this eastern portion traffic will be detoured on it while the existing structure is removed and the western portion constructed.

The proposed grade of Thickson Road will be at about elevation 337.0 and the grade of Hwy. 401 will be at about 312.0. The existing ground in the vicinity of the proposed structure site varies from elevation 322.0 to elevation 323.5. This indicates that the widening of the existing Hwy. 401 will be constructed in a cut section about 10.0 ft. on the north and about 11.5 ft. on the south side below ground level, while the Thickson Road will be constructed on an embankment up to 10.5 ft. high at the north and 12.5 ft. high at the south side of the structure.

### Structure Foundations.

The present proposals are for a two span structure. The following recommendations pertain to the design and construction of the structure.

### North and South Abutments (Ref. BH 1&2, 5&6)

The glacial till deposit composed of heterogeneous mixture of clayey silt, sand and gravel is competent to support a spread footing design. If a closed type of abutment is contemplated the footing may be founded within the glacial till deposit. The footing founding levels for the abutments are given in the table below.

Footings Founding Elevation Ft.

North &amp; South Abutments

West Side

313

North &amp; South Abutments

East Side

319

The abutment footing founding level should be stepped up from west to east side. Footings founded as described above can be designed for a safe allowable load of 5 t.s.f.

Alternatively, if spill-thru abutments are contemplated the abutment can be founded on a compacted granular "A" pad. It would be necessary to excavate the existing fill down to an elevation varying from 313 (west side) to 319 (east side), and replace with well compacted granular "A". Footings constructed in such a manner can be design for an allowable load of 2 1/2 t.s.f.

In either case it will be necessary to provide a minimum earth cover of 4 feet above the base of the footing for frost protection purposes. For estimating the earth pressure on the abutment wall a coefficient of active earth pressure of  $K_A=0.33$  may be used if some movement at the top of the wall is anticipated; whereas if no movement of the top of the wall is expected a coefficient of earth pressure at rest of  $K_0=0.5$  may be used for design purposes.

Center Pier (ref. BH 3 & 4)

The existing Hwy. 401 grade will be at approximate elevation 312. It is believed that the reconstruction of Hwy. 401 in this area will be maintained at the same grade. In order to provide adequate frost protection the footing should be located at or below elevation 308. At this elevation an allowable bearing capacity of 5 t.s.f. may be used for design of foundation.

### Miscellaneous (Structure)

To estimate the horizontal resistance to sliding the following values should be used:

- A) Between rough concrete and the slightly cohesive glacial till. A sliding resistance of 2000 P.S.F.
- B) Between rough concrete and the non cohesive glacial till or the granular A pad, A coefficient of friction of 0.6

No dewatering problems are anticipated for the construction of the foundations. Any minor seepage or surface runoff into the excavations can be handled by pumping.

### Approaches

The approaches will require fills up to 12.5 ft. in height and cuts up to depth of 11.5 ft. No stability problems are anticipated for the proposed approach fills and cuts constructed with standard 2:1 slopes, providing the following procedures are carried out.

- A) Remove all topsoil within the plan limits of the fill.
- B) The additional fill to be keyed to existing according to the current M.T.C. "Benching of Earth Slopes Standard" (DD-414)

There will be some differential settlements between that portion of the newly constructed embankment over parent subsoil and that portion constructed over the existing Thickson Road embankment. If possible scheduling should be such that paving should be delayed as long as possible to minimize this differential settlement.

### Miscellaneous

The fieldwork was carried out during February 14 to 16, 1978 under the supervision of Mr. V. Korlu, Project Engineer, who also prepared this report.



The drilling equipment was owned and operated by Masters Soil Co. of Toronto. The report was reviewed by M. Devata, Supervising Engineer.

*M Maclean*

*for*

V. Korlu  
Project Engineer

*Bin Ly*  
*for*

M. Devata  
Supervising Engineer

MD/VK/ig

April, 1978

## APPENDIX

## 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:

$S_u$ (FSF)	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.  $\bar{C}U$  = 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

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

#### INDEX PROPERTIES

$\gamma$  UNIT WEIGHT OF SOIL (BULK DENSITY)  
 $\gamma_w$  UNIT WEIGHT OF WATER  
 $\gamma_d$  UNIT DRY WEIGHT OF SOIL (DRY DENSITY)  
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 $D_r$  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 =  $\frac{I_P \text{ of soil}}{I_P \text{ of } 2\mu m \text{ Soil Fraction}}$   
 $Om$  ORGANIC MATTER CONTENT  
 $S_r$  DEGREE OF SATURATION  
 $S$  SENSITIVITY =  $\frac{S_u \text{ (undisturbed)}}{S_u \text{ (remoulded)}}$

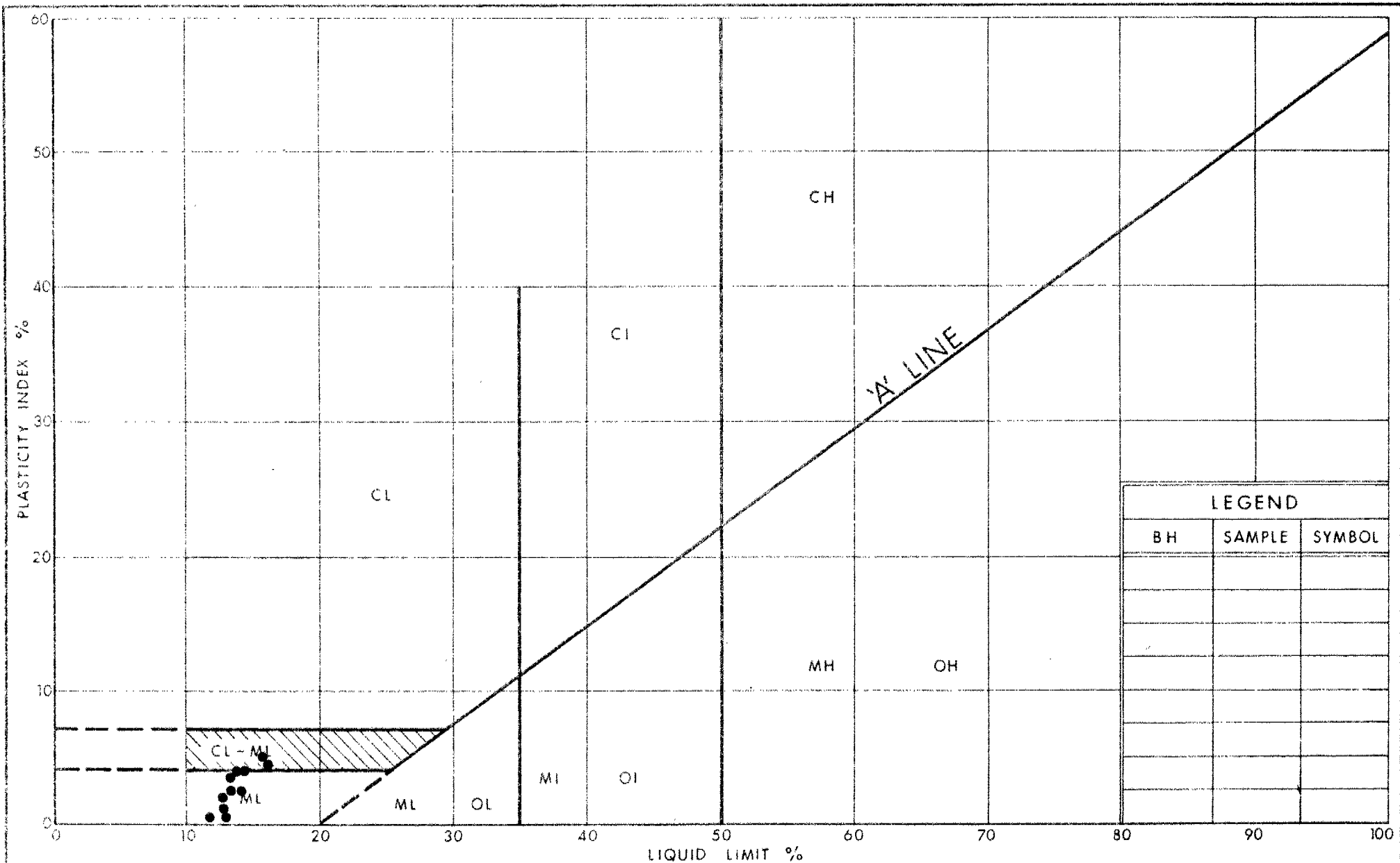
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 $\tau_f$  PEAK SHEAR STRENGTH  
 $\tau_R$  RESIDUAL SHEAR STRENGTH  
 $c$  COHESION INTERCEPT  
 $\sigma_1, \sigma_2, \sigma_3$  NORMAL PRINCIPAL STRESSES  
 $u$  PORE WATER PRESSURE  
 $u_e$  EXCESS  $u$   
 $r_u$  PORE PRESSURE RATIO  
 $q_u$  UNCONFINED COMPRESSIVE STRENGTH  
 $s_u$  UNDRAINED SHEAR STRENGTH  
 $\epsilon$  LINEAR STRAIN  
 $\gamma$  SHEAR STRAIN  
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 $E$  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:  
 $\phi'$  = EFFECTIVE ANGLE OF SHEARING RESISTANCE;  
 $\sigma'$  = EFFECTIVE NORMAL STRESS

#### HYDRAULIC TERMS

$h$  HYDRAULIC HEAD OR POTENTIAL  
 $q$  RATE OF DISCHARGE  
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 $k_h$   $k$  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)

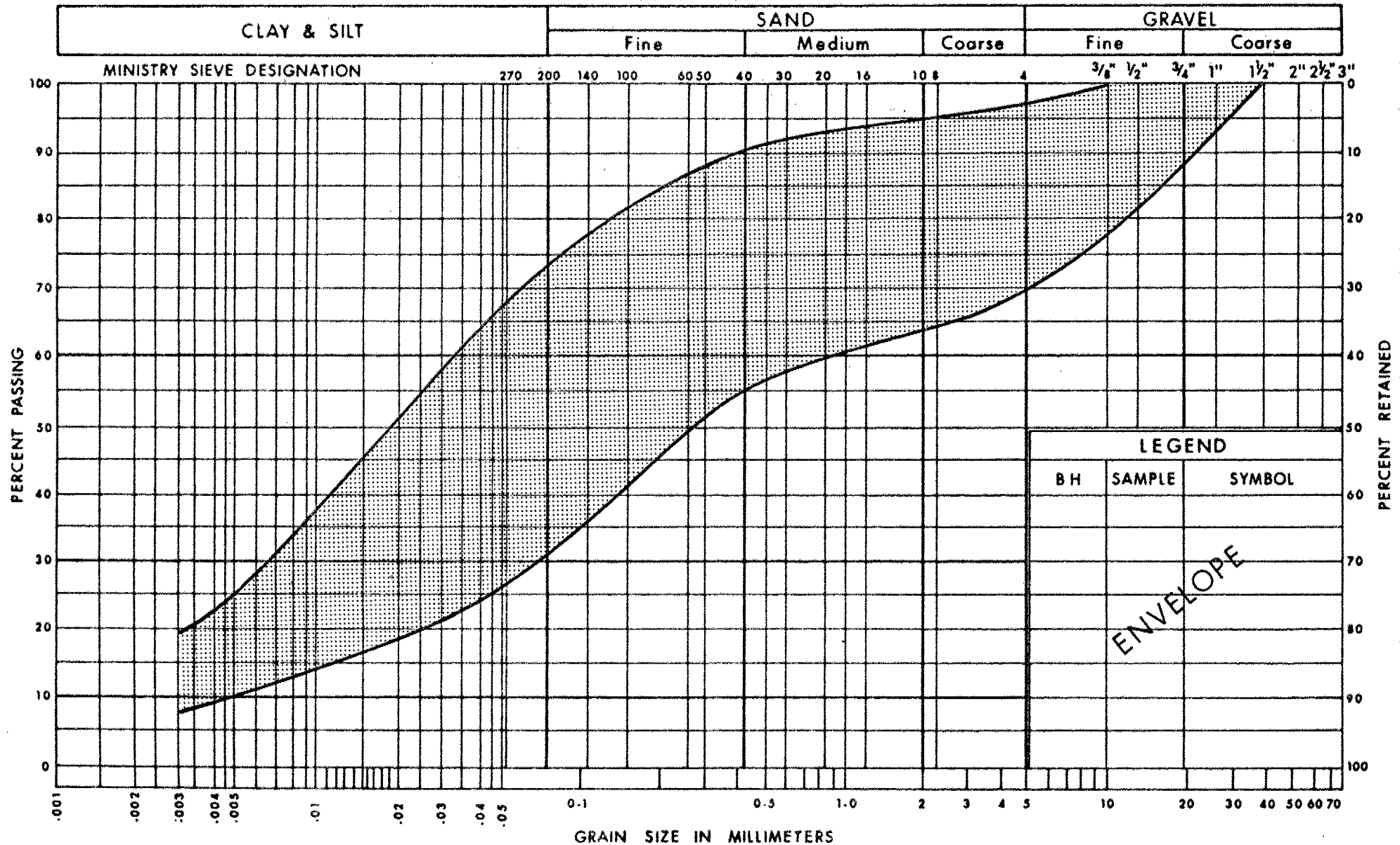
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PLASTICITY CHART  
GLACIAL TILL  
SLIGHTLY COHESIVE PORTION

FIG No 1

W P 38-77-01

## UNIFIED SOIL CLASSIFICATION SYSTEM



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## GRAIN SIZE DISTRIBUTION

### GLACIAL TILL

FIG No 2

W P 38-77-01



## RECORD OF BOREHOLE No 1

W P 38-77-01 LOCATION Co-ords. N. 15,940,906; E 1,56,759 ORIGINATED BY V.K.  
DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY V.K.  
DATUM Geodetic DATE February 14, 1978 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION, RESISTANCE PLOT					UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100		
329.0	Ground Level													
0.0	Fill													
	Clayey Silt with sand		1	SS	10									4 44 36 16
	and traces of gravel		2	SS	5									
	and organic		3	SS	11									3 31 36 30
	Firm to Stiff		4	SS	31									
313.0														
16.0	Glacial Till		5	SS	100	/5"								
	Het. Mix. Clayey		6	SS	110	/10"								21 39 27 13
	Silt Sand and		7	SS	50									
	Gravel Hard		8	SS	95	/9"								
	Brown-Grey Changing to		9	SS	129									
	Het. Mix. Silt		10	SS	126	/9"								8 43 43 6
	Sand and Gravel													
	V. Dense													
283.2														
45.8	End of Borehole													

## RECORD OF BOREHOLE No 2

W P 38-77-01 LOCATION Co-ords. N. 15,940,935; E 1,156,861 ORIGINATED BY V.K.  
DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY V.K.  
DATUM Geodetic DATE February 14, 1978 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100		
322.2	Ground Level													
0.0	Topsoil													
	Glacial Till		1	SS	53									
	Het. Mix. Claye Silt		2	SS	153	/11"								6 42 42 10
	Sand and Gravel		3	SS	137									
	Hard		4	SS	79									7 35 43 15
	Changing to Het. Mix.		5	SS	156									
	Silt, Sand and Gravel		6	SS	157									
	V. Dense		7	SS	171	/9"								
	Brown-Grey		8	SS	100	/3"								4 25 57 14
293.0														
29.2	End of Borehole													

+3, x5: Numbers refer to  
Sensitivity

20  
15  $\diamond$  5 (%) STRAIN AT FAILURE  
10



HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 3

W P 38-77-01 LOCATION Co-ords. N. 15,940,779; E. 1,156,791 ORIGINATED BY V.K.  
 DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY V.K.  
 DATUM Geodetic DATE February 16, 1978 CHECKED BY CP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
309.2	Ground Level																
0.0	Topsoil																
	Glacial Till		1	SS	35												
	Het. Mix. Clayey Silt, Sand and Gravel		2	SS	77												
	Hard		3	SS	81												
			4	SS	174	/10"											
	Brown Grey		5	SS	156												
	Changing to Het. Mix. silt sand and gravel.		6	SS	184	/11"											
			7	SS	181	/10"											
	Very Dense		8	SS	103	/6"											
278.7	End of Borehole																

RECORD OF BOREHOLE No 4

W P 38-77-01 LOCATION Co-ords. N. 15,940,833; E. 1,156,888 ORIGINATED BY V.K.  
 DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY V.K.  
 DATUM Geodetic DATE February 16, 1978 CHECKED BY CP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
312.5	Ground Level																
0.0	Topsoil																
	Glacial Till		1	SS	49												
	Het. Mixture of Clayey Silt, Sand and Gravel		2	SS	121	/10"											
	Hard		3	SS	76												
	Changing to Het. Mix. Silt, Sand and Gravel		4	SS	100	/5"											
	V. Dense		5	SS	144	/11"											
			6	SS	153	/10"											
			7	SS	101												
281.0	End of Borehole																

+3, x5: Numbers refer to Sensitivity

20  
15  
5  
5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION



Ontario Communications

HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 5

W P 38-77-01 LOCATION Co-ords. N. 15,940,677; E. 1,156,833 ORIGINATED BY V.K.  
DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY V.K.  
DATUM Geodetic DATE February 15, 1978 CHECKED BY CP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W <sub>p</sub> NATURAL MOISTURE CONTENT W LIQUID LIMIT W <sub>L</sub> WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
329.0	Ground Level										
0.0	Fill Clayey silt with sand and some gravel and traces of organics		1	SS	22						16 37 32 15
			2	SS	12						0 43 39 18
			3	SS	7						
314.0	Firm to V. Stiff		4	SS	9						
15.0	Glacial Till Het. Mixture of Clayey Silt, Sand and Gravel		5	SS	37						26 35 29 10
	Hard brown grey		6	SS	133						
	Changing to Het. Mixture of Silt Sand and gravel		7	SS	153						10 37 43 10
	V. Dense		8	SS	145						
			9	SS	126						
282.5			10	SS	91						
46.5	End of Borehole										

RECORD OF BOREHOLE No 6

W P 38-77-01 LOCATION Co-ords. N. 15,940,706; E 1,156,934 ORIGINATED BY V.K.  
DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY V.K.  
DATUM Geodetic DATE February 15, 1978 CHECKED BY CP

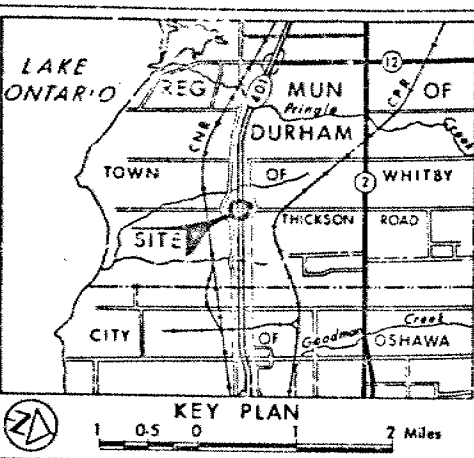
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W <sub>p</sub> NATURAL MOISTURE CONTENT W LIQUID LIMIT W <sub>L</sub> WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
321.0	Ground Level										
0.0	Topsoil										
	Glacial Till Het. Mixture Clayey Silt Sand and Gravel		1	SS	129						13 36 31 20
	Hard		2	SS	122						
	Changing to Het. Mixture of Silt Sand and Gravel		3	SS	120						28 34 29 9
	V. Dense		4	SS	115						
			5	SS	162						
			6	SS	154						
			7	SS	192						7 43 41 9
290.5			8	SS	94						
30.5	End of Borehole										

+3, x5: Numbers refer to Sensitivity

20  
15-5 (%) STRAIN AT FAILURE  
10

OFFICE REPORT ON SOIL EXPLORATION





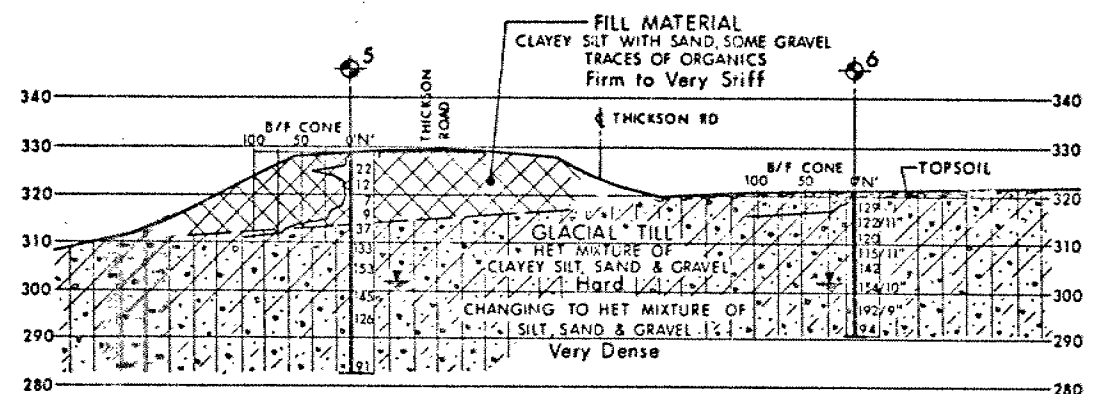
LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- Blows/ft (Std Pen Test, 350 ft lbs energy)
- CONE Blows/ft (60° Cone, 350 ft lbs energy)
- WL at time of investigation Feb 1978

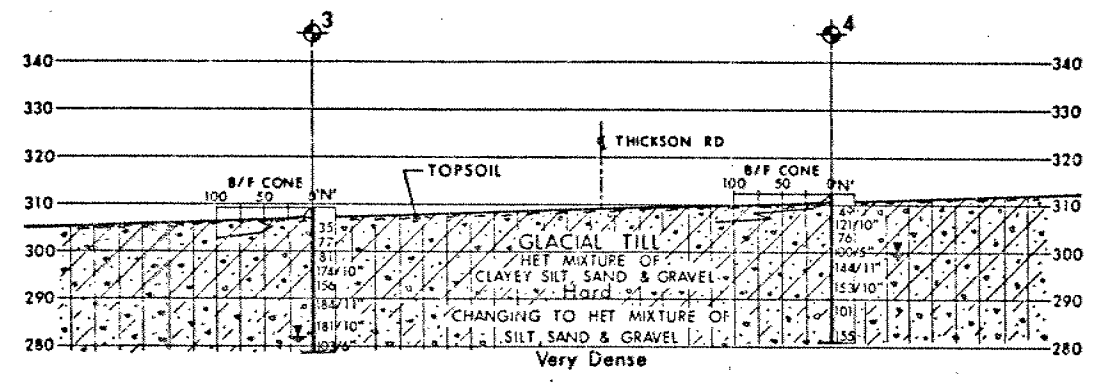
No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	329.0	15 940 906	1156 759
2	322.2	15 940 935	1156 661
3	309.2	15 940 779	1156 791
4	312.5	15 940 833	1156 888
5	329.0	15 940 677	1156 833
6	321.0	15 940 706	1156 934

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

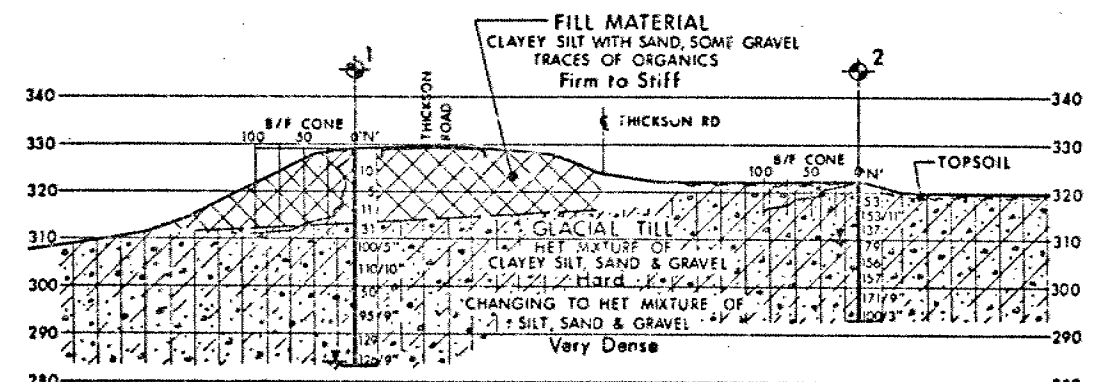
REVISIONS	DATE	BY	DESCRIPTION



A-A

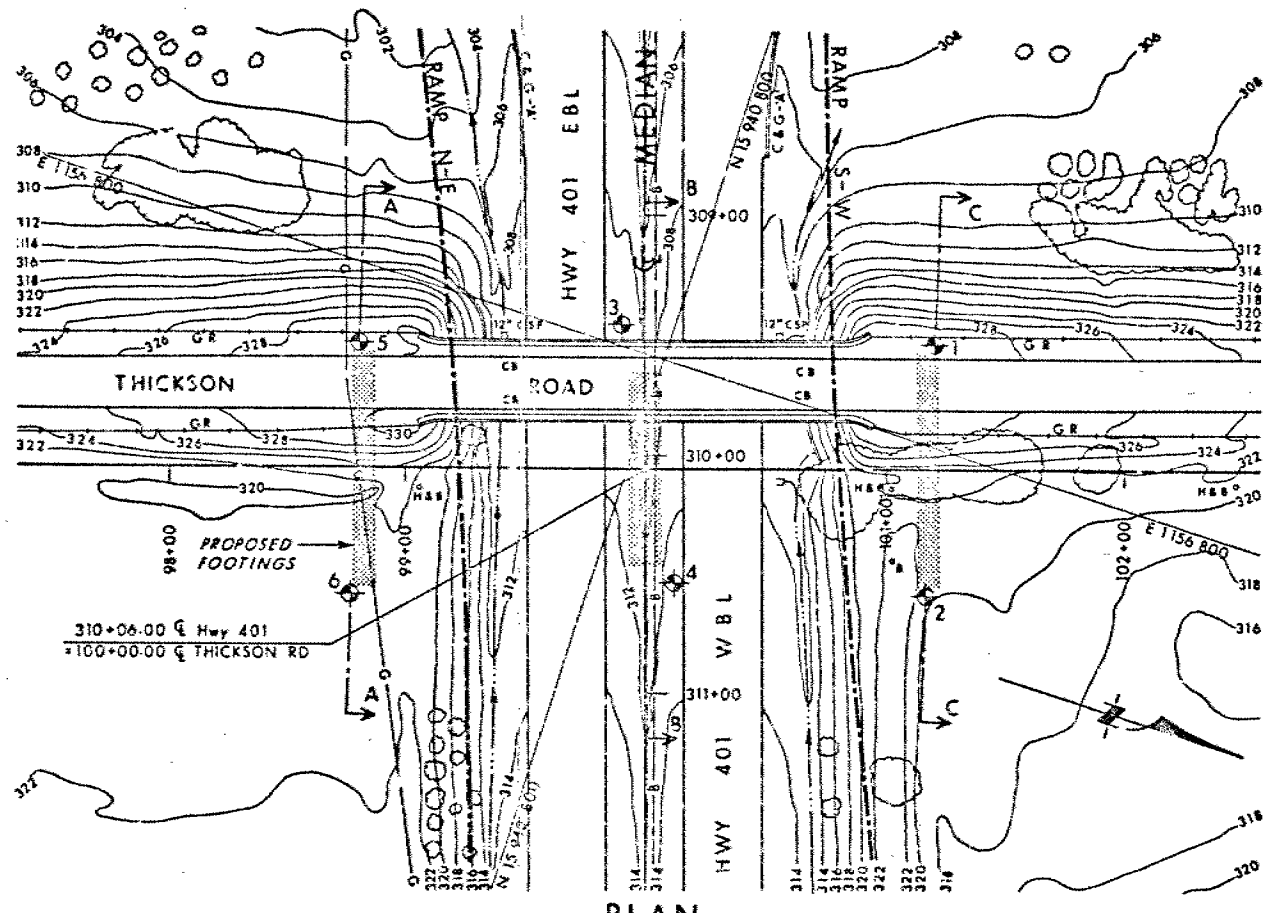


B-B



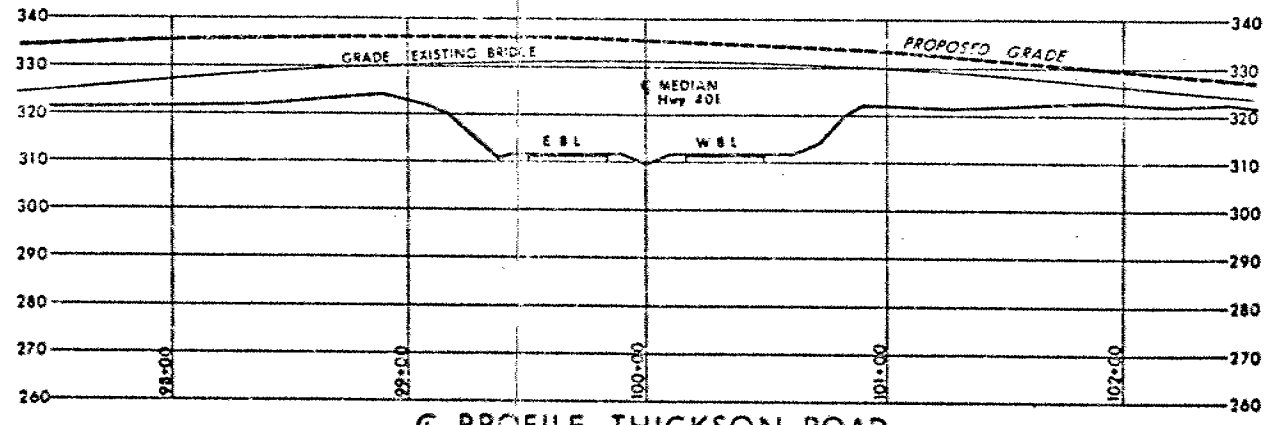
C-C  
SECTIONS

SCALE  
20 10 0 20 FT



PLAN

SCALE  
40 20 0 40 FT



E & W PROFILE THICKSON ROAD

SCALE  
HORIZ 40 20 0 40 FT  
VERT 20 10 0 20 FT

DeLeuw Cather

GENERAL NOTES:

- CLASS OF CONCRETE  
DECK 5000 P.S.I.  
PIER COLS. & BARRIER WALLS 4000 P.S.I.  
REMAINDER 3000 P.S.I.  
REINFORCING STEEL GRADE 400  
REINFORCING BARS WITH DESIGNATION C 41  
END OF BAR MARKS SHALL BE COATED BARS  
CLEAR COVER ON REINFORCING STEEL  
FOOTINGS & ABUTMENTS 3"  
PIER COLUMNS 2"  
DECK TOP 2"  
DECK BOTTOM 2"  
APPROACH SLABS 2"  
AND/OR AS NOTED ON DRAWINGS.

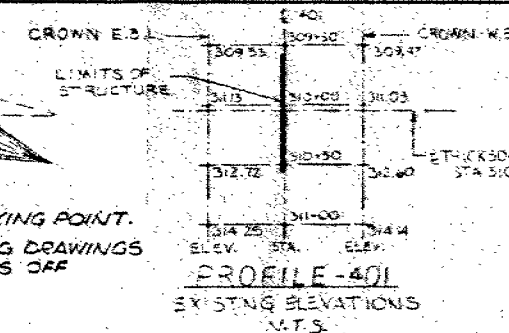
CONSTRUCTION NOTES

THE CONTRACTOR SHALL FINISH THE BEARING SEATS DEAD LEVEL TO THE SPECIFIED ELEVATIONS WITH A TOLERANCE OF  $\pm 1/8"$ .

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

LIST OF DRAWINGS:

- 22-171-1. GENERAL PLAN.
2. BOREHOLE LOCATIONS & SOIL STRATA.
3. FOOTING LAYOUT & DETAILS.
4. FOOTING REINFORCEMENT.
5. SOUTH ABUTMENT.
6. NORTH ABUTMENT.
7. PIER COLUMNS.
8. DECK LAYOUT, SCREED ELEV. AND BEARINGS.
9. CABLE DETAILS I.
10. CABLE DETAILS II.
11. DECK REINFORCEMENT I.
12. DECK REINFORCEMENT II.
13. BARRIER WALL WITH SIDEWALK.
14. STEEL RAILING (SINGLE TUBE).
15. 20 FT. APPROACH SLAB.
16. DETAILS OF CONC. SLOPE PAVING.
17. STANDARD DETAILS I.
18. STANDARD DETAILS II.
19. STANDARD DETAILS III.
20. AS CONSTRUCTED ELEV. & DIM.
21. ROADWAY PROTECTION (A) & (B).
22. ROADWAY PROTECTION (C) & (D).
23. STRUCTURE REMOVAL & ROADWAY PROTECTION (E).



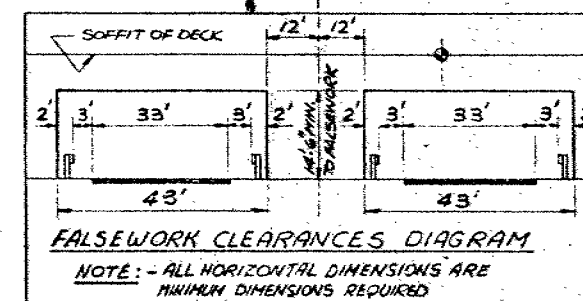
PROFILE - THICKSON RD.

N.T.S.

CONSTRUCT. STAGING

1. CONSTRUCT ROADWAY PROTECTION (A) & (B).
2. CONSTRUCT EAST STRUCTURE.
3. CONSTRUCT ROADWAY PROTECTION (C) & (D).
4. DIVERT THICKSON TRAFFIC TO EAST STRUCTURE.
5. REMOVE WINGWALLS OF THE EXIST. STRUCTURE.
6. CONSTRUCT ROADWAY PROTECTION (E).
7. DIVERT HWY 401 TRAFFIC BEHIND EXISTING BRIDGE ABUTMENTS.
8. REMOVE REMAINDER OF EXISTING STRUCTURE.
9. DIVERT 401 TRAFFIC TO EXISTING - EASTBOUND & WESTBOUND LANES.
10. CONSTRUCT WEST STRUCTURE.

NOTE: IF STAGE II DETOUR IS CARRIED OUT BETWEEN NOV. 15 & MAY 15, SPECIAL FROST PROTECTION SHALL BE PROVIDED FOR THE EAST STRUCTURE FOOTINGS. (SEE DWG. 3)

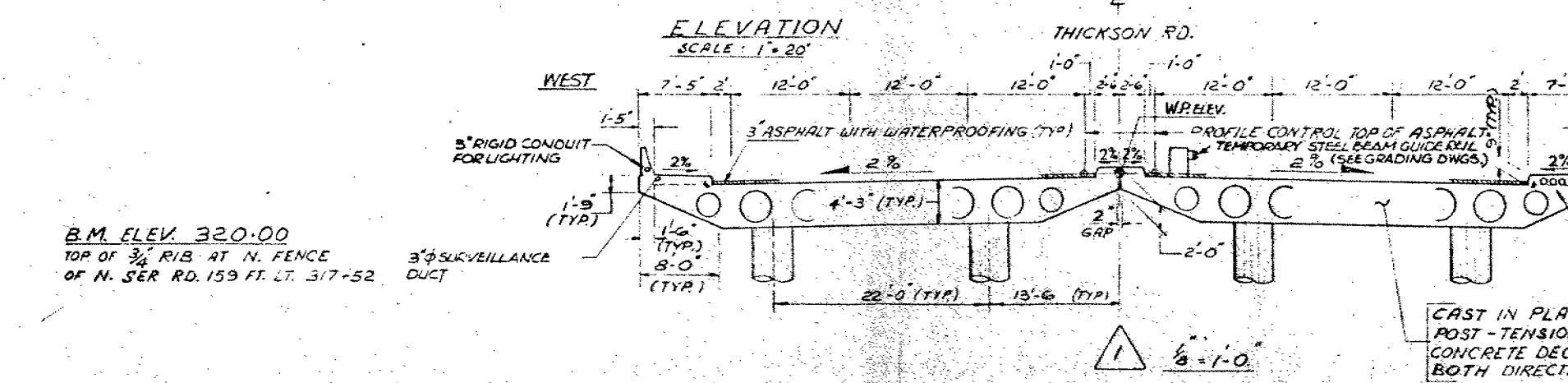
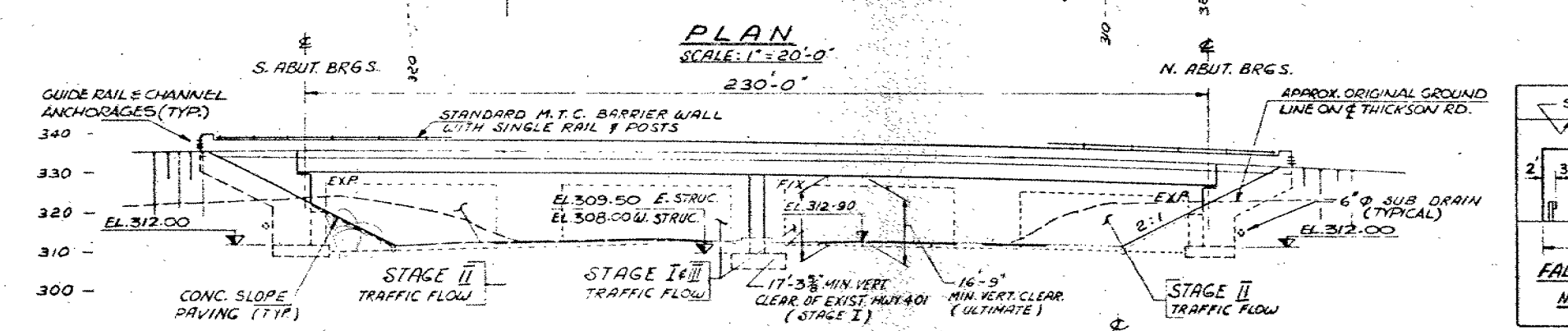
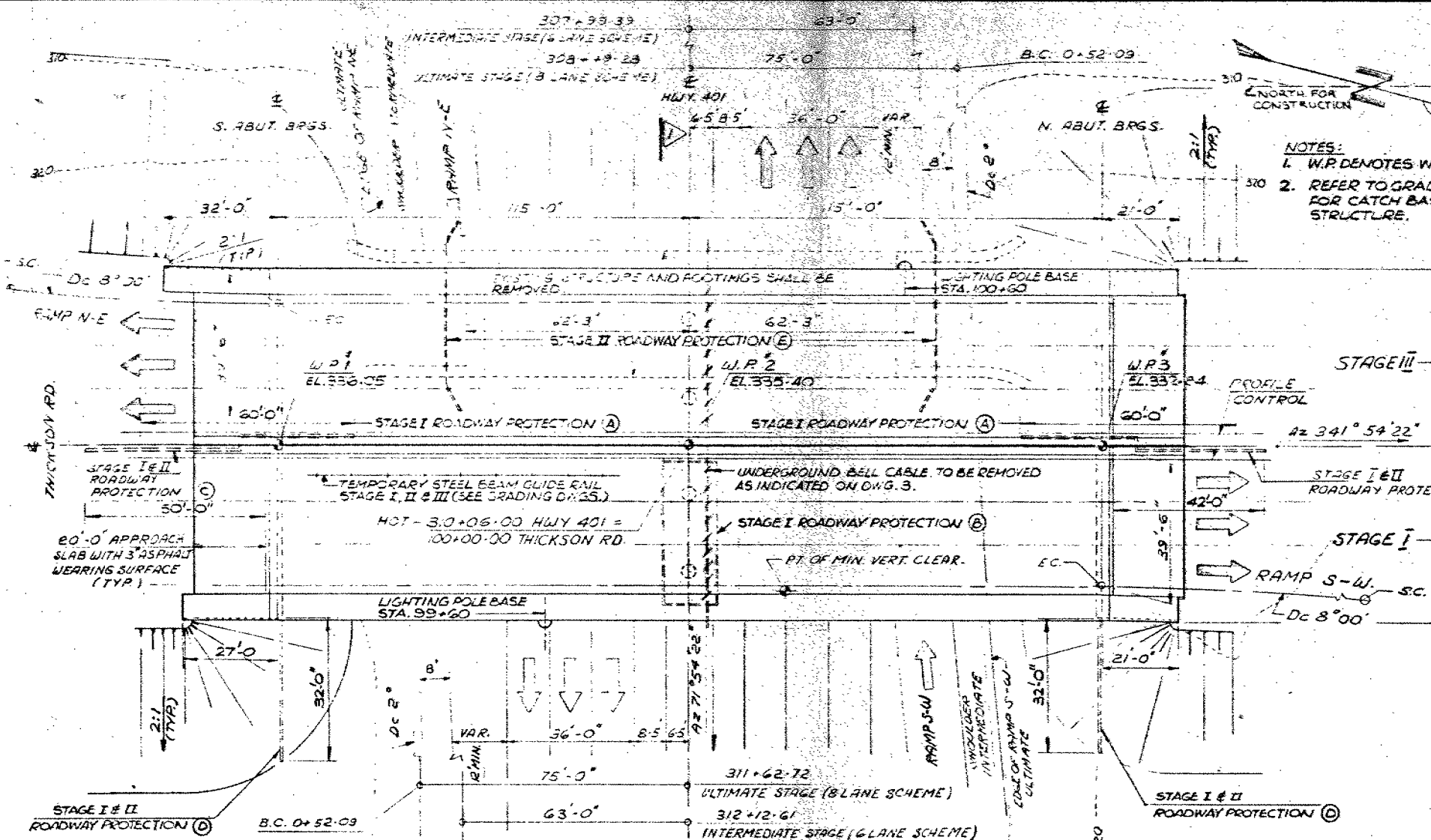


EXISTING STRUCTURE DRAWINGS

- 3-20-1. PLAN & ELEVATION.
- 3-20-2. DETAIL.



FOR REDUCED PLAN



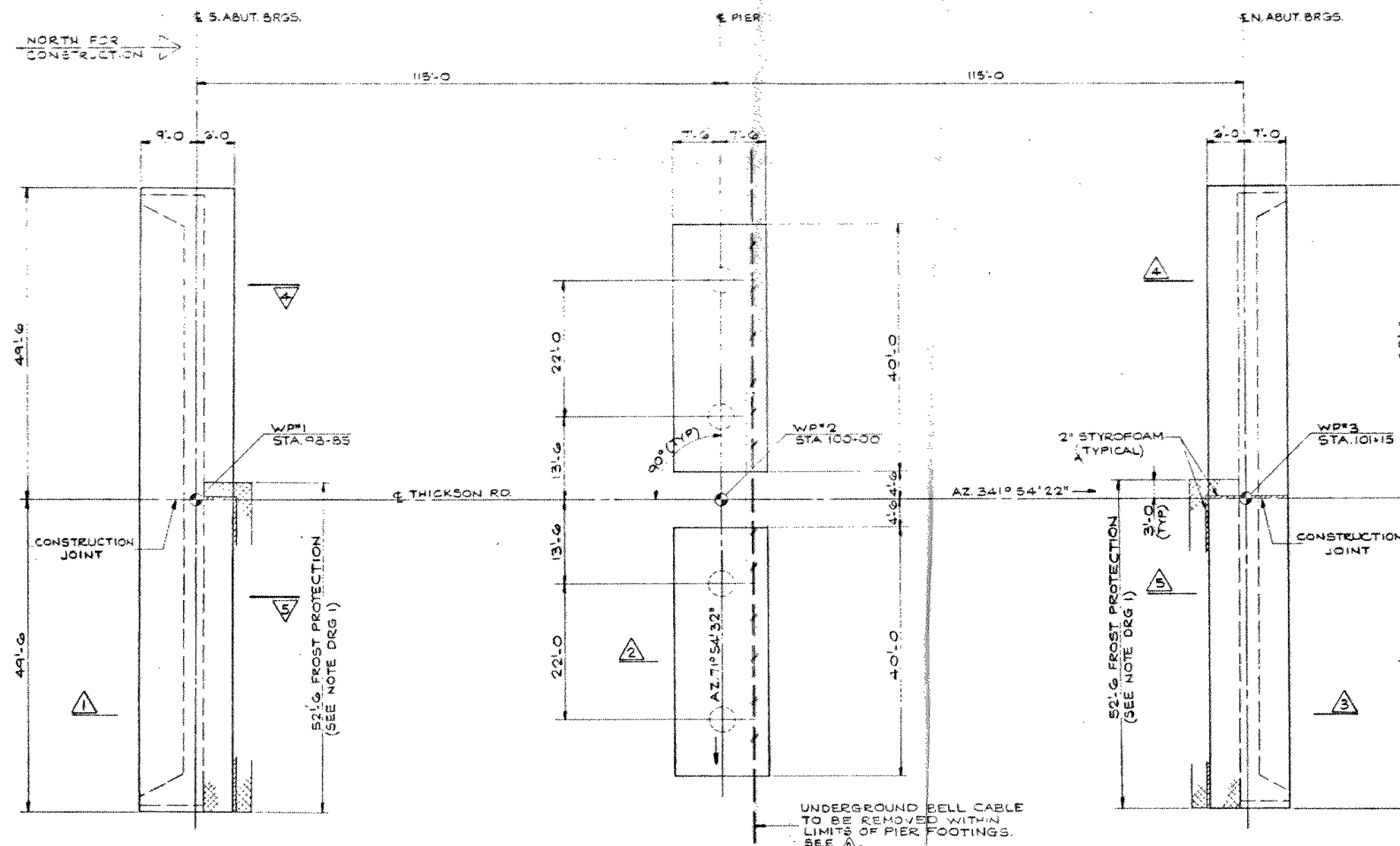
CAST IN PLACE  
POST-TENSIONED  
CONCRETE DECK (TYP)  
BOTH DIRECTIONS

CONCRETE QUANTITIES:

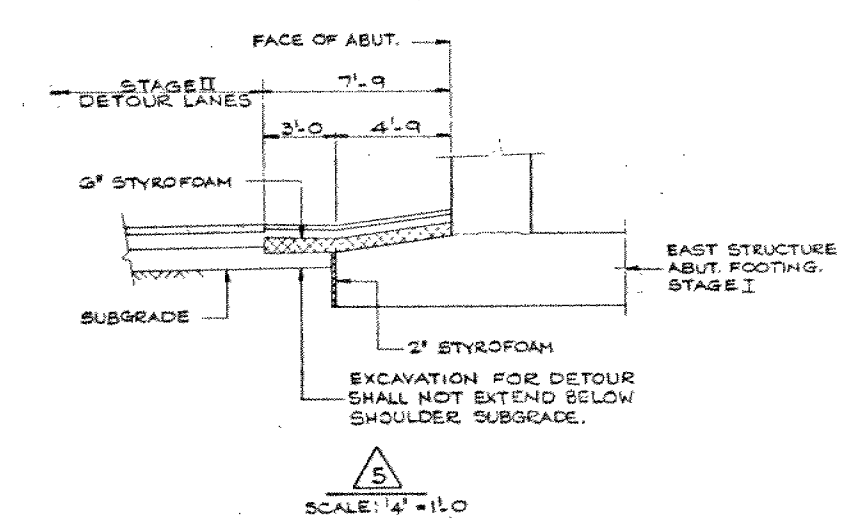
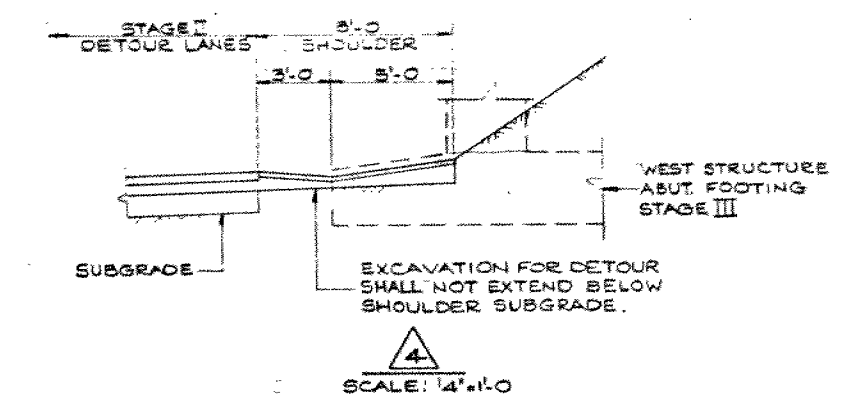
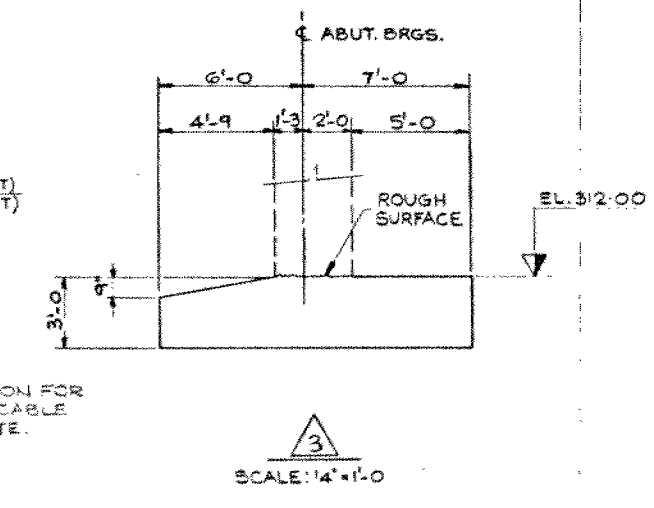
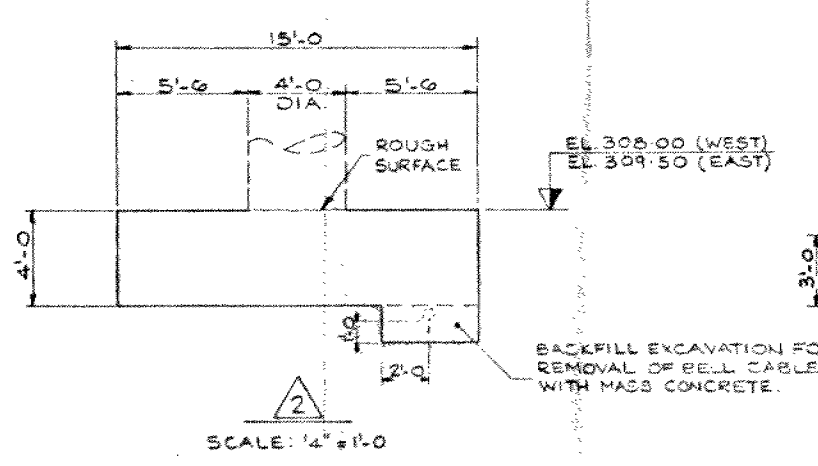
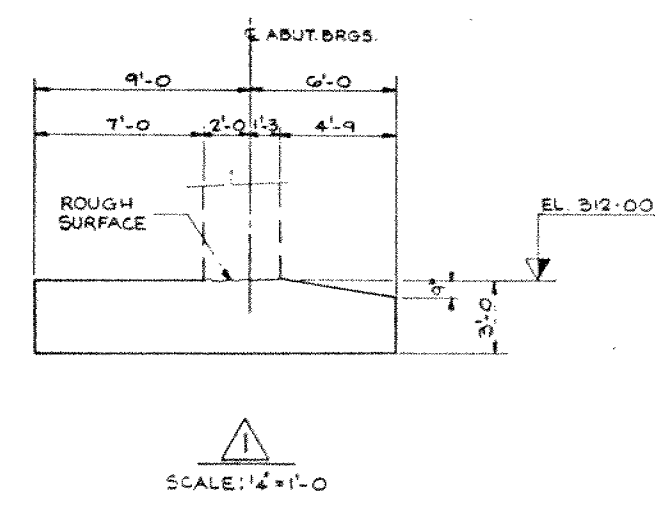
CONCRETE QUANTITIES ARE LISTED BELOW FOR APPROPRIATE CONCRETE LUMP SUM ITEMS.

1. CONCRETE IN PIERS, ABUTMENTS AND WINGWALLS. 3000 P.S.I. — 578 cu yd  
4000 P.S.I. — 41 cu yd
2. PRESTRESSED CONCRETE BRIDGE DECK. 2480 cu yd
3. CONCRETE IN BARRIER WALLS. 43 cu yd
4. CONCRETE IN APPROACH SLABS. 117 cu yd
5. CONCRETE IN SLOPE PAVING. 93 cu yd

DATE	BY	DESCRIPTION
DESIGN	SSS	CHECK B.M. LOADING 20-44 DATE 1/1/79
DRAWING	J.A.	CHECK G.S. SITE No 22-171-02 DWG. 1.



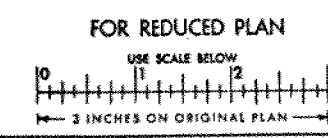
PLAN  
SCALE: 3/32" = 1'-0"



CONT No WP No 38-77-02		SHEET
THICKSON ROAD UNDERPASS		
FOOTING LAYOUT AND DETAILS		
De Leuw Cather		

WORKING POINT COORDINATES		
WP	NORTH	EAST
1	940297.944	153124.335
2	940807.053	153124.335
3	940297.873	153124.332

NOTES  
1. STYROFOAM FOR FROST PROTECTION SHALL BE LEFT IN PLACE.



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	05	CHECK	S.C. LOADING
DRAWING	05	CHECK	S.C. SITE

# De Leuw Cather

CONSULTING ENGINEERS AND PLANNERS  
INGÉNIEURS CONSEILS ET PLANIFICATEURS

November 21, 1978

Our Ref: 04566-00

Mr. M. Devata  
Supervising Engineer  
Soils Mechanics Office  
Ministry of Transportation  
and Communications  
Room 315, Central Building  
1201 Wilson Avenue  
Downsview, Ontario  
M3M 1J8

Attention: Mr. B. Ly, Senior Engineer

Dear Sir:

Re: Thickson Road Underpass  
W.P. 38-77-02, Site 22-171  
District 6, Toronto

Further to our telephone conversation on November 16, 1978, enclosed is a preliminary print of the Footing Layout and Detail drawing for the above structure. Also enclosed are copies of layout sketches showing elevations of the structure for reference.

As suggested we have designed the abutment footings for 4 t.s.f. due to the shallow depth of footing in undisturbed soil. Please advise us if the same consideration applies to the pier footings. *Piers --- 5 tsf*

We would be pleased to receive details for frost protection of footing which you have used on other projects. *→ see drawing*

Yours very truly,

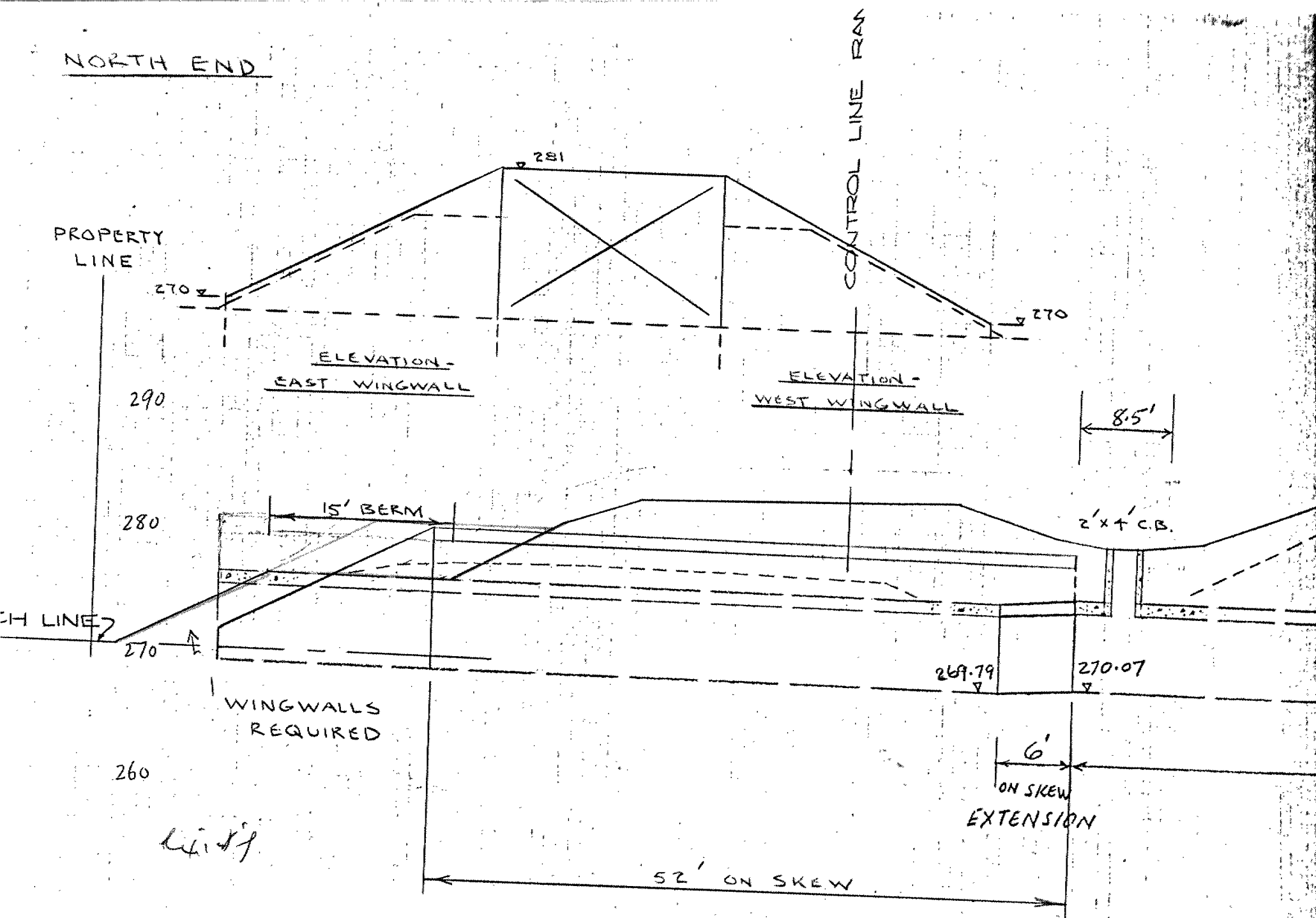
*G.S. Saunders*  
G.S. Saunders, P. Eng.  
Senior Structural Engineer

GSS:md  
Encls.

cc: Mr. W.L. Lin - Design Engineer  
Eastern Section



NORTH END



Mr. R.D. Gunter  
Head  
Regional Geotechnical Section  
Central Region

Soil Mechanics Section  
Engineering Materials Office  
Room 315, Central Building

79 01 16

Re: Stability Requirements for the Realigned N,S-W  
and W-N, S Ramps Over Corbett Creek  
Hwy. 401 - Thickson Road Interchange  
W.P. 38-77-01, Hwy. 401, District 6, Toronto

---

In conjunction with the proposed improvement of Hwy. 401 - Thickson Road Interchange, the existing N,S-W and W-N, S ramps will be realigned. In addition, the profile grades will also be raised by about 6 feet and 10 feet higher respectively at the Corbett Creek crossing. Our previous investigations done for the relocation of the North and South Service Roads indicate that the general area of Corbett Creek is usually underlain by unfavorable subsoil conditions, generally consisting of organic silts followed by soft compressible clays. In view of this, the Regional Geotechnical Section has recently requested the Soil Mechanics Section to assess the stability of the ramps at the above mentioned location. In our stability analysis the data such as the cross-sections of the ramp and the subsoil properties supplied by the Regional Geotechnical Section was used. Our analyses concluded the following.

Stability of the Fills of the N,S-W Ramp

The fills will have a total height of about 14 feet above the average ground level. In order to achieve an adequate factor of safety for the fills against a deep seated failure, a mid-height 15 foot wide counterbalancing berm (Figure 1) will be required. This berm can be tapered off on either side of the creek at a rate of 1 foot per every 20 running feet.

Stability of the Fills of the W-N, S Ramp

The height of the fills will be in the order of 21 feet. Because of a somewhat more favorable subsoil condition at this location, the fill was found to have an adequate factor of safety with respect to a rotational type of failure if it is constructed with side slopes of 2H:1V (Figure 2).

cont'd.....

It should be noted that the fills will impose additional unsymmetrical loadings on the existing culvert footings. Further, it is inferred from the findings of our previous investigations done in the general area that large differential settlements induced by the proposed fills can be anticipated. Because of a lack of pertinent information regarding the consolidation characteristics of the subsoil at this site and the design details of the existing culvert footings, specific comments with respect to the probable amount of consolidation settlements and the ultimate bearing capacity of the footings under the unsymmetrical loadings cannot be made at this stage. Perhaps as a precaution it may be advisable to use a flexible type of culvert instead of a rigid one which will accommodate the large possible differential settlements and also the unsymmetrical loading conditions that might prevail.

B. Ly  
Senior Engineer

For: M. Devata  
Supervising Engineer

BL/MD/gs

Attach.

cc: M.R. Ernesaks  
G.C.E. Burkhardt  
Files/

Soil Type	$C_u$	$\phi_u$	$\gamma$	$\gamma'$
1	0	30	130	68
2	1500	0	110	48
3	300	0	100	38
4	0	35	130	68

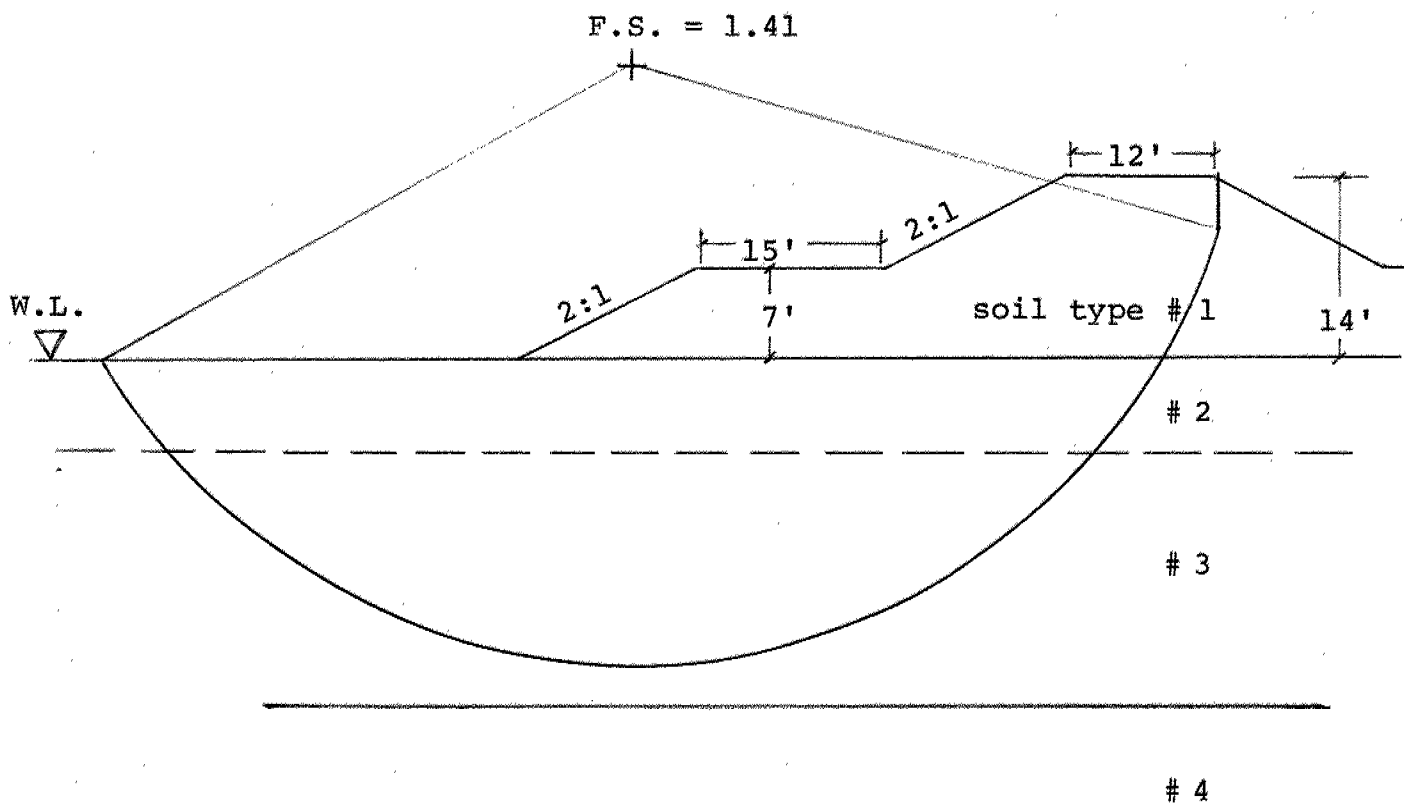
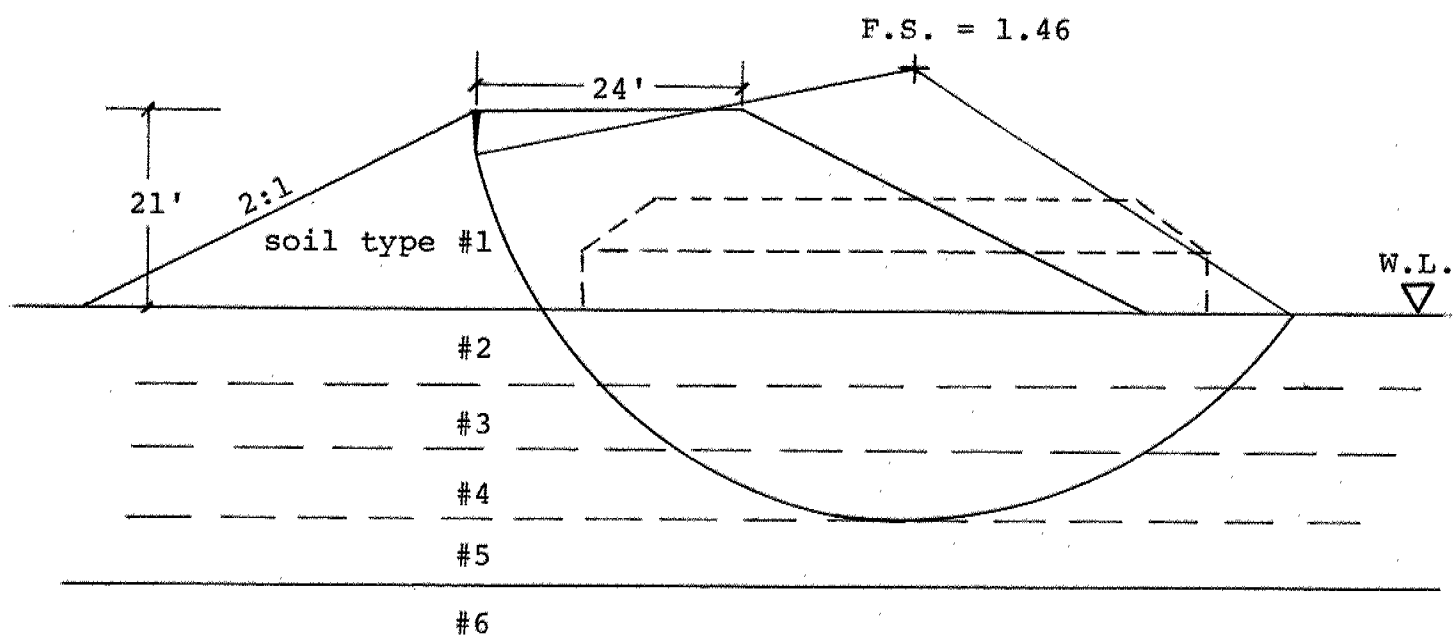


Figure 1 Stability Analysis For the Fills  
of the Realigned N, S-W Ramp at Sta. 302+76+

Note: Subsoil stratigraphy based on B.H. #9



Figure 2 Stability Analysis for the Fills of  
the Realigned W-N, S Ramp at Sta. 302+76+



Note: Assumed subsoil stratigraphy based on data supplied by the Region.

Soil Type	$C_u$	$\phi_u$	$\gamma$	$\gamma'$
1	0	30	130	68
2	2000	0	110	48
3	850	0	105	43
4	450	0	100	38
5	700	0	105	43
6	0	35	130	68



## Memorandum

To: Mr. W.C. Friedmann  
Supervisor  
Planning Unit  
Central Region  
Attention: Mr. L. Dutchak  
Our File Ref.

From: Regional Geotechnical Office  
Central Region

Date: 77 06 23

In Reply to



Subject:

W.P. 38-77-01, Site 22-171  
Proposed Relocation of South Service Road  
South-West Quadrant of Thickson Road / Hwy. 401  
Toronto District

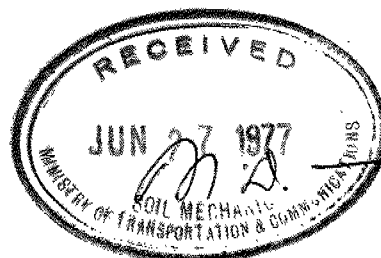
Following your request for a soils investigation to be carried out at the above mentioned site, a total of 20 boreholes were drilled to a depth ranging from 4.0' to 13.0'. Some of these holes, primarily those within the vicinity of the proposed 20 foot embankment fill, were progressed even further with the use of a field vane.

This area is located within the physiographic region known as the Iroquois Plain. This lowland area borders Lake Ontario and was previously inundated in the late Pleistocene times by Lake Iroquois. Within this immediate area, it is characterized primarily by Darlington loam with some areas of till plains, drumlins, and silty lacustrine deposits.

The existing Thickson Road, at the point of intersection with the proposed relocated South Service Road, consists of 3" of asphalt followed by 7" of brown sand and gravel and 20" of fine sand all overlying a stratum of brown fine sandy loam. The existing South Service Road, at the point of intersection with the proposed relocated South Service Road, consists of 5" of asphalt followed by 6" of brown sand and gravel and 12" of brown fine sand all overlying brown very fine sandy loam to sandy clay loam.

In general, throughout the area of the investigation, the upper 6" to 16" consists of a dark brown clay loam topsoil. In the area from Thickson Road to Corbett Creek, this topsoil layer is followed by 6' to 7' of brown light clay underlain by a zone of grey wet light to medium clay till. Vane tests carried out indicated that the majority of the deposit was stiff with a soft to firm layer from 15 feet to 25 feet below ground level. Shear strengths as low as 200 - 450 p.s.f. were recorded within a layer 16 feet to 18 feet below ground level.

In the area from the existing South Service Road to Corbett Creek the topsoil layer is followed by a layer 2 feet to 4 feet thick of brown light to medium clay underlain by a zone of greyish brown wet medium clay till.



continued .... 2.

*M.M. mm*  
↓  
*Filer*

In all boreholes where vane tests were carried out, the vane encountered numerous cobbles and boulders within the clay fill zone at depths ranging from 14 feet to 25 feet. At these depths, no further penetration with the vane was possible.

Vane test results indicated shear strengths in excess of 1,000 p.s.f. within the upper 15 feet. Shear strengths as low as 400 p.s.f. were encountered within the zone from 15 feet to 20 feet below ground level with an average value at about 600 p.s.f. Below this soft to firm zone, however, the shear strength again increases to a value above 800 p.s.f. with an average value of about 1,000 p.s.f.

Contrary to an earlier soils investigation carried out on the north side of Highway 401, no swamp area was encountered within the vicinity or adjacent to the proposed relocated South Service Road. On the basis of previous investigations, it is apparent that the subsurface conditions improve as one approaches the lake shore.

Water level readings taken within the open boreholes indicated the prevailing groundwater to exist from 3'± B.G.L. adjacent to Corbett Creek to 7'± B.G.L. at Station 97+00. The downward drainage within this area varies from moderately good to imperfect.

### RECOMMENDATIONS

#### 1.) Granular Material

Throughout the extent of this project the following granular depths are recommended.

Granular "A" - 6"  
Granular "C" - 15"

#### 2.) Hot Mix

a.) A.A.D.T. smaller than 2000

1½" H.L.4     Surface Course  
1" H.L.2  
2½" TOTAL

continued .... 3.

b.) A.A.D.T. 2000 - 6000

1½" H.L.4  
1½" H.L.4  
1" H.L.2  
3 3/4" TOTAL

c.) A.A.D.T. greater than 6000

1½" H.L.1 Surface Course  
1½" H.L.4 Upper Binder Course  
1½" H.L.4 Lower Binder Course  
1" H.L.2  
5½" TOTAL

3.) Embankment Fill

Due to the existence of a soft moderately sensitive clay layer extending from a level 15 feet to 20 feet below ground level, it is recommended not to exceed the proposed 20 feet embankment fill of Profile 'A' in order to ensure its stability.

RVV/RDG:saw

  
R. Van Veen

c.c. W.W. Kulmatickas ✓  
R. Fitzgibbon  
J. Anderson

For: R.D. Gunter  
Head, Geotechnical Section