

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 40P2-40
40P2-31

DIST. 4 REGION

W.P. No. 166-60-01

CONT. No. 87-20

W. O. No.

STR. SITE No. 23-89-311

HWY. No. 403/401

LOCATION 403 W.B.L. HWY 401

INTERCHANGE

No of PAGES -

=====

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

FOUNDATION INVESTIGATION REPORT

CONTRACT NO 87-20



Ministry of
Transportation and
Communications

I N D E X

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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.

EXPLANATION OF TERMS USED IN REPORT

2

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

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

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

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

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

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

R Q D (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

	SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING		VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING		VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_f	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{\min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	KN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	KN/m^3	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	KN/m^3	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	KN/m^3	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	KN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL	e_{\max}	1, %	VOID RATIO IN LOOSEST STATE	j	KN/m^3	SEEPAGE FORCE
γ'	KN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

FOUNDATION INVESTIGATION REPORT

For

W.P. 166-60-01, Site 23-89-311

Hwy. 401 Interchange, (Hwy. 403 W.B.L.)

Hwy. 403, District 2, LondonINTRODUCTION:

This report summarizes the results of the foundation investigation required for the proposed structure and approach embankments at this site.

The fieldwork was conducted during the period from 82 07 21 - 27 utilizing a continuous-flight auger machine equipped with 82 mm I.D. hollow-stem augers.

This work consisted of 5 sampled boreholes/dynamic cone penetration tests.

SITE DESCRIPTION

The site is located east of Co. Rd. 15 along Hwy. 401 at Woodstock (Lot 13, Con. II, Twp. Norwich, Geog. Twp. (East) Oxford, County of Oxford).

Physiographically, the site is located in the Oxford Till Plain.

SUBSURFACE CONDITIONSGeneral

The Record of Borehole Sheets (Appendix) illustrate the conditions at the borehole locations. The location and elevations of the boreholes, and a stratigraphical profile based on the borehole data are shown on Drawing No. 2 of the contract DWG's.

The overburden at this site is composed of till. A predominantly cohesive silty clay till overlies a predominantly non-cohesive sandy silt to silty sand till. The boundary between these two general soil types dips gradually towards the south (from elev. 290.1 m at BH #1 to elev. 284.7 m at BH #5).

Silty Clay (CL), Some Sand, Trace Gravel

This firm to hard till material extends from the surface for depths ranging from 10.1 m at BH #1 to 21.3 m at BH #5. The deposit is generally silty clay of low plasticity containing some sand and traces of gravel. The sand content generally increases with depth especially at BH #1, #2 and #3. Occasional layers of dense silty sand were encountered within this deposit at BH #1 and BH #4, generally between Elev. 300 and elev. 298.

Physical properties of the cohesive portion of this material, as determined from field and laboratory tests, are summarized below:

	<u>Range</u>	<u>Average</u>
Natural Water Content (w)	8.0-14.5%	11.3%
Liquid Limit (W _L)	14.0-26.0%	20.0%
Plastic Limit (W _p)	11.0-15.0%	13.0%

Generally the material did not fail during field vane shear testing, indicating undisturbed shear strengths in excess of 107 kPa. A field vane shear strength value of 34.5 kPa, obtained near elev. 298 m at BH #3, was considered to be non-representative of the general deposit. Shear strength values from unconfined compression tests of similar material in the immediate vicinity of this site led to the selection of 150 kPa as the average shear strength for the silty clay till deposit.

Figure 1 illustrates a typical grain size distribution for the cohesive portion of this deposit.

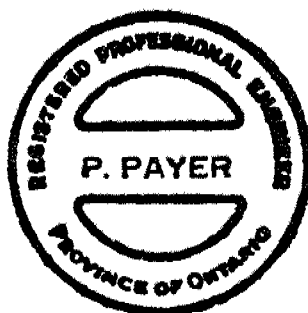
Sandy Silt to Silty Sand, Some Gravel, Trace Clay

This very dense till deposit underlies the silty clay till across the entire site. As indicated in Drawing No. 2, occasional layers of cohesive silty clay were encountered between elev. 286 m and elev. 282 m at BH #1 and BH #3. Occasional boulders were encountered while augering within this deposit. The natural water content of the non-cohesive portion of this deposit ranged from 6.0 - 10.5%.

Figure 2 illustrates a typical grain size distribution for the noncohesive portion of this deposit.

Groundwater

The groundwater elevation was estimated at 298 m. This estimate was based on field observations, data from previous foundation investigations in the immediate vicinity, and well records.



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

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

APPENDIX

RECORD OF BOREHOLE No 1

METRIC

W P 166-60-01 LOCATION Sta. 11 + 257 E.W.B.L. ORIGINATED BY BY
DIST 2 HWY 403/401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY DD
DATUM Geodetic DATE 82 07 22 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
300.2	Ground Surface																
0.0																	
	occ. layers of Silty Sand, Compact		1	SS	16	**											5 42 43 10
			2	SS	17												9 40 37 14
	Silty Clay (CL)		3	SS	29												
	Some Sand		4	SS	24												
	Trace Gravel		5	SS	11												
	Stiff to Very Stiff (Till)		6	SS	10												
	with Sand		7	SS	20												
			8	SS	18												5 43 38 14
290.1																	
10.1	Sandy Silt to Silty Sand		9	SS	100/	24 cm											19 37 37 7
	Some Gravel																
	Trace Clay		10	SS	100/	22 cm											15 37 42 6
	Very Dense (Till)		11	SS	100/	22 cm											
	occ. layers of Silty Clay (CL) Hard		12	SS	100/	18 cm											
			13	SS	100/	24 cm											
281.9			14	SS	100/	19 cm											
18.3	End of Borehole																*C _u > 107kPa
	** Stabilized ground water level estimated from well records																

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 2

METRIC

W P 166-60-01 LOCATION Sta. 11 + 278 f W.B.L. ORIGINATED BY BY
DIST 2 HWY 403/401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY DD
DATUM Geodetic DATE 82 07 23 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100					
300.7	Ground Surface													
0.0	Silty Clay (CL)													
	Some Sand		1	SS	13									
	Trace Gravel		2	SS	18									
	Stiff to Hard		3	SS	33									
	(Till)		4	SS	34									
			5	SS	29									
			6	SS	10									
			7	SS	20									
	with Sand		8	SS	15									
			9	SS	16									
289.1														
11.6	Sandy Silt to Silty Sand, Some Gravel		10	SS	100/	18 cm								
	Trace Clay													
	Very Dense													
	(Till)													
286.7			11	SS	100/	17 cm								
14.0	End of Borehole													
	** Stabilized ground water level estimated from well records													*Cu > 107kPa

RECORD OF BOREHOLE No 3

METRIC

W P 166-60-01 LOCATION Sta. 11 + 320 E W.B.L. ORIGINATED BY BY
DIST 2 HWY 403/401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY DD
DATUM Geodetic DATE 82 07 21 CHECKED BY DD

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20 40 60 80 100	20 40 60 80 100					
302.1	Ground Surface												GR SA SI CL
0.0	Silty Clay (CL)												
	Some Sand		1	SS	16								
	Trace Gravel		2	SS	18								
	Firm to Hard		3	SS	15								
	(Till)		4	SS	5	**							
			5	SS	22								
			6	SS	24								
			7	SS	17								
			8	SS	20								
			9	SS	21								
	with Sand		10	SS	12								
289.0													
13.1	Sandy Silt to Silty Sand		11	SS	100/	15 cm							
	Some Gravel												
	Trace Clay		12	SS	100								
	Very Dense												
	(Till)												
	occ. layers of Silty Clay (CL) Hard		13	SS	100								
280.3			14	SS	100								
21.8	End of Borehole												*Cu > 107kPa
	** Stabilized ground water level estimated from well records												

OFFICE REPORT, ON SOIL EXPLORATION



RECORD OF BOREHOLE No 4

METRIC

W P 166-60-01 LOCATION Sta. 11 + 354 @ W.B.L. ORIGINATED BY BY
DIST 2 HWY 403/401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY DD
DATUM Geodetic DATE 82 07 27 CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 20 40 60 80 100	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES							
301.9	Ground Surface											
0.0			1	SS	31							
			2	SS	29							
	occ. layers of Silty Sand, Compact		3	SS	19							
			4	SS	15							
	Silty Clay (CL)											
	Some Sand		5	SS	21							
	Trace Gravel											
	Stiff to Hard (Till)		6	SS	26							
			7	SS	29							
			8	SS	36							
			9	SS	47							
			10	SS	32							
288.0			11	SS	57							
13.9	Sandy Silt to Silty Sand Some Gravel Trace Clay Very Dense (Till)		12	SS	100							4 30 56 10
284.7			13	SS	100							9 43 42 6
17.2	End of Borehole ** Stabilized ground water level estimated from well records											*C _u > 107kPa

RECORD OF BOREHOLE No 5

METRIC

W P 166-60-01 LOCATION Sta. 11 + 375, 5.0 m Rt. of W.B.L. ORIGINATED BY BY
DIST 2 HWY 403/401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY DD
DATUM Geodetic DATE 82 07 23-26 CHECKED BY DD

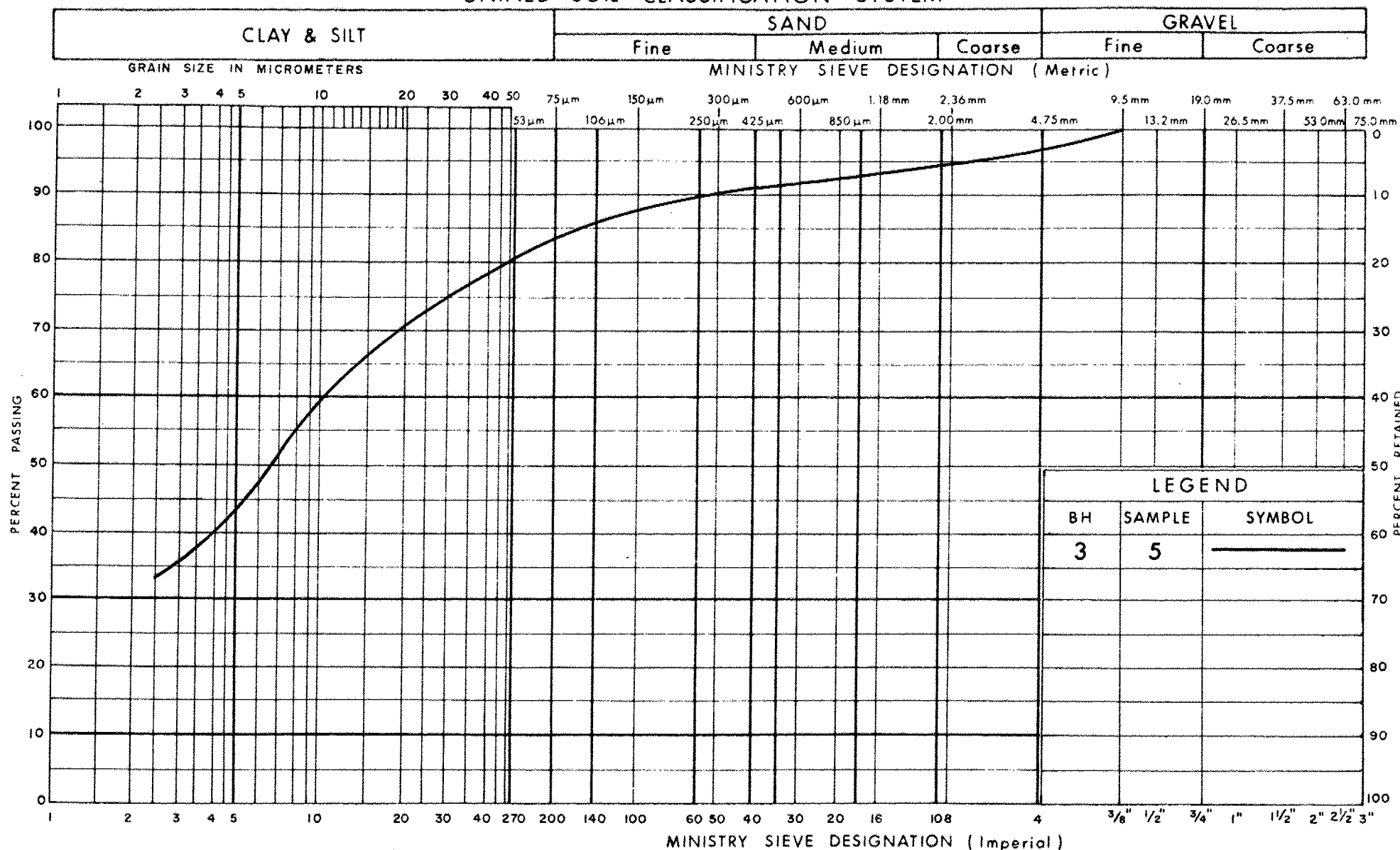
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
306.0	Ground Surface													
0.0	Silty Clay (CL) Some Sand Trace Gravel Stiff to Hard (Till)		1	SS	29									
			2	SS	37									
			3	SS	29									
			4	SS	15									
			5	SS	19									
			6	SS	17									
			7	SS	17									
			8	SS	27									
			9	SS	19									
			10	SS	25									
			11	SS	27									
			12	SS	29									
			13	SS	31									
284.7			14	SS	100	20 cm								
21.3	Sandy Silt to Silty Sand Some Gravel, Trace Clay Very Dense (Till)		15	SS	100	28 cm								
282.5	Probable Boulder Refusal to Auger End of Borehole ** Stabilized ground water level estimated from well records													*C _u > 107kPa

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

UNIFIED SOIL CLASSIFICATION SYSTEM



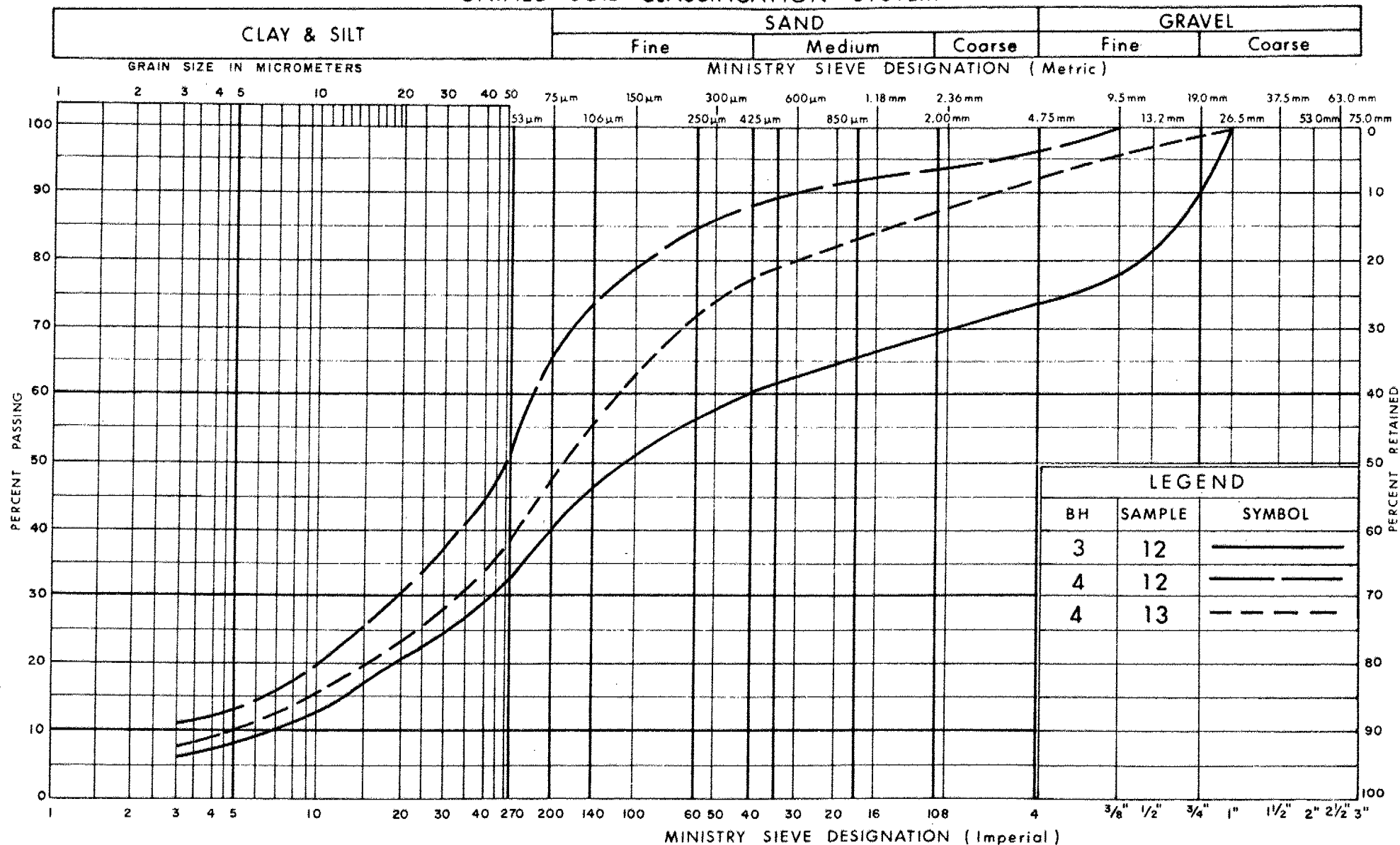
Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION
SILTY CLAY (Till)
SOME SAND TRACE GRAVEL

FIG No 1

W P 166-60-01

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

 Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION
 SANDY SILT TO SILTY SAND
 SOME GRAVEL TRACE CLAY

FIG No 2

W P 166-60-01

DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS

MEMORANDUM

TO: Mr. A. P. Watt, (2)
Reg. Structural Planning Eng.,
Southwestern Region,
London, Ont.

FROM: Foundations Office,
Design Services Branch,
West Bldg., Downsview.

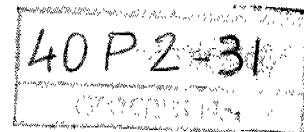
ATTENTION:

DATE: August 10, 1972

OUR FILE REF.

IN REPLY TO **AUG 24 1972**

SUBJECT:



FOUNDATION INVESTIGATION REPORT
For

The Hwy. #401 Overpass of Proposed
Hwy. #403; 20.6 Mi. West of Brantford
West Limits District #4 Hamilton
W.O. 72-11048 - W.P. 166-60-01

Attached we are forwarding to you our detailed foundation investigation report on the subsoil conditions existing at the above-mentioned site.

We believe that the factual data and recommendations contained therein will prove adequate for your design requirements. Should additional information be required, please do not hesitate to contact our Office.

A. G. Stermac,
PRINCIPAL FOUNDATIONS ENGINEER.

AGS/ht
Attch.

c.c. D. W. Farren
B. R. Davis
A. Rutka
A. McConnell
C. R. Robertson
B. J. Giroux
J. R. Roy
G. A. Wrong
B. A. Singh

Foundations Files
Documents

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FOUNDATION INVESTIGATION REPORT

For

The Hwy. #401 Overpass of Proposed
Hwy. #403; 20.6 Mi. West of Brantford
West Limits ~~District #4~~ Hamilton
W.O. 72-11048 -- W.P. 166-60-01

1. INTRODUCTION:

The Foundations Office was requested to carry out an investigation at the site of the Hwy. #401 overpass of proposed Hwy. #403, Line 'E', W.B.L., some 20.6 miles west of Brantford west limits. The request was contained in a memo, dated March 21, 1972 by Mr. S. Jants, Bridge Planning Technician, Southwestern Region.

The subsequent fieldwork, as well as the laboratory testing programme were supervised by this Office, while the boreholes were located and related to geodetic benchmark by personnel of the Engineering Survey Office, Southwestern Region. Presented in this report are the results of the investigations, together with recommendations concerning structure foundations.

2. DESCRIPTION OF THE SITE AND GEOLOGY:

The proposed bridge site is situated within the right of way of existing Hwy. #401. The top of pavement of the highway at this location is around general groundlevel. The area within the right of way is conventionally landscaped. The fields in the vicinity are occupied by farms, usually growing crops. The terrain has a gentle gradient, sloping from east to west. Geologically, the proposed crossing site belongs to what is known to be the "Oxford Till Plain" physiographic region. The surface of this region is drumlinized, with good drumlines appearing south of Woodstock, where the glacial deposit apparently overrode an older moraine and faint drumlines and flutings further north. The till is a pale brown calcareous boulder loam, in which Onondaga limestone is the dominant material.

3. FIELD AND LABORATORY INVESTIGATIONS:

One sampled borehole and two dynamic cone penetration tests were carried out at each proposed footing location, as shown on the accompanying Drawing #72-11048A. The borings were implemented by means of a Bombardier mounted hollow stem auger (CME - 55), taking samples at regular intervals. Undisturbed samples were recovered by Shelby Tubes, which were pushed 18 inches into the soils, using the hydraulic head of the auger. Split spoon samplers were advanced by performing Standard Penetration Tests. Penetration resistances expressed as the number of hammer blows of a 140 lbs. hammer falling 30 inches for 1 ft. penetration, are recorded on the borelog sheets.

Samples were identified in the field, and again upon arrival in the laboratory. Laboratory testings were carried out on representative samples in order to determine natural moisture contents, Atterberg limits and grain-size distributions of the various deposits. The undrained shear strengths of the undisturbed samples were determined by laboratory unconfined compression tests. Laboratory test results are compiled in the borelogs attached to this report.

4. SOIL CONDITIONS:

4.1) General:

Heterogeneous glacial deposits, consisting of clayey silts and sandy silts with some gravel were found in the boreholes. Due to the very stiff to hard consistency of the clayey silts all the dynamic cone penetration tests reached resistances of 100 blows/ft. or over, around elevation 971-981 ft., some 9 - 18 ft. below groundlevel.

Detailed descriptions of the deposits are as follows:

4.2) Clayey Silts with some Sand and Traces of Gravel:

This is the uppermost deposit, found in the borings, except in B.H. #1, where the clayey silts are overlain by a 13 ft. thick fine sandy silt stratum. The depth of the clayey silts varies between 27 ft. and 42 ft., extending to geodetic elevations of 944 ft. - 957 ft. Penetration resistances ranging from 15 blows/ft. to 63 blows/ft. were noted within this soil, indicating very stiff to hard consistencies. The minimum value of laboratory

undrained shear strength was 1,500 PSF, the corresponding field strength being 2,000 PSF, estimated by the obtained 'N' values. The material exhibited slight plasticity; Atterberg limit tests resulted in plastic limits of 13% - 20% and liquid limits of 22% - 34%, with natural moisture contents of 10% - 19%.

Several grain-size analyses were carried out, the range of constituent particles being computed to be as follows: gravel - 1-6%, sand - 9-25%, silt - 50-61% and clay - 13-40%.

4.3) Sandy Silt with some Clay and Gravel:

Below the clayey silts, sandy silts to silty sands with some clay and gravel were encountered, extending to the bottom of the holes at el. 929 Ft. - 940 Ft. High penetration resistances were observed within this stratum, 'N' values being between 24 blows/ft. and much above 100 blows/ft. Based on these values, the relative density of the deposit was classified to be compact to very dense. The heterogeneous and unsorted nature of the soils was confirmed by particle size analyses. The gravel size particles range from 8% to 24%, the sands from 22% to 37%, silts from 29% to 49% and the clays from 9% to 20%.

Occasionally, samples had some slight plasticity, with approximately 12% plastic limit and 19% liquid limit. The majority of the samples, however, were found to be nonplastic. All the samples were terminated within the very dense portion of the sandy silts.

4.4) Groundwater Conditions:

Groundwater levels were observed in the borings, which were kept open until equilibrium watertable was reached. Such levels were established some 3 - 7 ft. below general groundsurface, corresponding to elevations of 978 ft. - 988 ft.

5. DISCUSSION AND RECOMMENDATIONS:

5.1) General:

The overpass structure at the crossing of Hwy. #401 and proposed Hwy. #403, Line "E" W.B.L. is planned to be a 4-span bridge with approach fills of some 32 ft. height at the west approach and some 24 - 26 ft. height at the east. The grade of Hwy. #403 at the crossing is proposed to be at

elevation 1,013.5 ft. It is assumed that the abutments will be of the spill through type.

Subsoil at the footing locations was observed to be clayey silt with some sand and traces of gravel of very stiff to hard consistency, underlain by sandy silt with some clay and gravel of compact to very dense relative density.

5.2) Structure Foundation:

On account of the very stiff to hard consistency of the surficial deposit, the use of spread footings appear to be feasible and the most economical. Footings may be designed at four feet below existing groundlevel or anywhere below this depth. Based on the minimum average 'N' value, safe design loads of 3.0 TSF are recommended to be used for design purposes on the footing bases. Four ft. cover should be maintained over the bottom of the footings for frost protection.

Perched abutments may also be supported on piles, driven through the approach fills, which should be devoid of bouldery material at the locations of the piles. It is believed that steel tubular piles will be the most practical in these soils, piles being driven to 70 Ton/pile capacity, according to Standard BD - 82 - 7. In estimating pile lengths, it is assumed that on 12 3/4 inch diameter steel tubes 70 Ton/pile design loads will be reached by driving the piles to approximate elevation 935 ft - 940 ft.

Due to the cohesive strength of the clayey silts no dewatering problems are foreseen in the footing excavations. Any seepage which may occur, could be handled by conventional pumping from shallow sumps around the perimeter of the oversized excavations. If the excavations are kept open for some time a lean concrete working slab should be poured at the base to prevent it from softening.

No stability problems will be encountered for the approach fills, provided that they are built with 2 horizontal to 1 vertical slopes.

6. MISCELLANEOUS:

The fieldwork was carried out during the period of May 19 - 26, 1972, under supervision of Mr. L.J. Hodge, Engineering Student.

Equipment used was owned and operated by P.V.K. Drilling Company, Burford, Ontario.

This report was written by Mr. A.K. Barsvary, Senior Foundations Engineer, and reviewed by Mr. K.G. Selby, Supervising Foundations Engineer.



[Handwritten Signature]
Barsvary, P. Eng.

[Handwritten Signature]

K.G. Selby, P. Eng.

AKB/ht

August 2, 1972

APPENDIX I

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 1

FOUNDATION SECTION

JOB 72-11048

LOCATION Sta. 111 + 19 80' Lt. Ø Hwy. 401

ORIGINATED BY LJH

W.P. 166-60-0

BORING DATE May 24 & 26, 1972

COMPILED BY LJH

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		20	40	60	80	100	WATER CONTENT % 10 20 30				
990.6	Ground Level															
0.0	Fine sandy silt, traces of clay and gravel. Very Stiff		1	SS	26											
			2	SS	30											
			3	SS	26											
977.6	Brown		4	SS	29											
13.0	Clayey silt, traces of gravel. Very stiff to hard. Grey		5	SS	15											
			6	SS	29											
			7	SS	38											
			8	SS	36											
			9	SS	41											
			10	SS	29											
953.6																
37.0	Sandy silt, some clay and gravel. Very Dense & Hard Grey		11	SS	52											
			12	SS	100											
			13	SS	100 1/4"											
			14	SS	100 1/2"											
936.6																
54.0	End of Borehole															

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 2

FOUNDATION SECTION

JOB 72-11048

LOCATION Sta. 112 + 02 85' Lt. Ø Hwy. 407

ORIGINATED BY LJH

W.P. 166-60-0

BORING DATE May 24, 1972

COMPILED BY LJH

DATUM Geodetic

BOREHOLE TYPE Dynamic Cone Test

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ P.C.F.	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		20	40	60	80	100	SHEAR STRENGTH P.S.F.					WATER CONTENT %
988.2	Ground Level																
0.0																	
						980											
974.3																	
13.9	End of Cone Test					970											

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 3

FOUNDATION SECTION

JOB 72-11048

LOCATION Sta. 111 + 54 47 Lt. 0 Hwy. 401

ORIGINATED BY KH L.J.H.

W.P. 166-60-0

BORING DATE May 24, 1972

COMPILED BY L.J.H.

DATUM Geodetic

BOREHOLE TYPE Dynamic Cone Test

CHECKED BY AK

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ P.C.F.	REMARKS		
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		20	40	60	80	100	SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE					WATER CONTENT % w_p — w — w_L	
990.4	Ground Level					990												
0.0																		
981.4																		
9.0	End of Cone Test					980												

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 4

FOUNDATION SECTION

JOB 72-11048

LOCATION Sta. 112 + 38 53' Lt. Ø Hwy. 401

ORIGINATED BY LJH

W.P. 166-60-0

BORING DATE May 23, 1972

COMPILED BY LJH

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger and Cone Test

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — w _L PLASTIC LIMIT — w _p WATER CONTENT — w			BULK DENSITY γ P.C.F.	REMARKS GR. SA. SI. CL.
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT					WATER CONTENT %				
							SHEAR STRENGTH P.S.F.					w _p — w — w _L				
							20	40	60	80	100					
							1000 2000					10 20 30				
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE									
989.3	Ground Level															
0.0	Clayey silt with some sand & traces of gravel. Very Stiff to Hard. Grey		1	SS	23	980									135	3 17 55 25
			2	SS	24									1 11 58 30		
			3	SS	43									No water observed		
			4	SS	56											
			5	SS	63											
			6	SS	26											
			7	SS	18											
			8	SS	23	960								135	1 9 50 40	
			9	TW	PH											
			10	SS	48											
			11	SS	56											
952.8	36.5 Sandy silt to silty sand, some clay and gravel. Hard and Dense to Very Dense		12	SS	27	950								135	24 37 29 10	
			13	SS	115											
			14	SS	100											8 28 45 19
49.0	End of Borehole															

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 5

FOUNDATION SECTION

JOB 72-11048

LOCATION Sta. 112 + 08 2' Lt. Ø Hwy. 401

ORIGINATED BY LJH

W.P. 166-60-0

BORING DATE May 25, 1972

COMPILED BY LJH

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger & Cone Test

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT ——— w_L PLASTIC LIMIT ——— w_p WATER CONTENT ——— w			BULK DENSITY γ P.C.F.	REMARKS		
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT					w_p ——— w ——— w_L	WATER CONTENT % 10 20 30					
							SHEAR STRENGTH P.S.F.											
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE											
989.0	Ground Level																	
0.0	Clayey silt with traces of sand and gravel. Very Stiff to Hard. Grey		1	SS	26	980												
			2	SS	27													
			3	SS	27													
			4	SS	63													
			5	SS	52	970										142		
			6	SS	23													
			7	SS	19													
			8	TW	PH													
			9	SS	31	960										137		
			10	TW	PH													
957.0	Sandy silt with seam of clayey silt some clay, traces of gravel. Very Stiff to Hard. Grey		11	SS	31	950									114 60 25 6 40 40 14			
32.0			12	SS	24													
			13	SS	104 1/6"													
			14	SS	100 1/3"		940										9 34 43 14	
935.0			15	SS	100 1/2"													
54.0	End of Borehole																	

FOUNDATION SECTION

ORIGINATED BY LJH

COMPILED BY L J H

CHECKED BY

20
15- ϕ -5 % STRAIN AT FAILURE
10

FOUNDATION SECTION

CHECKED BY

20
15 — 5 % STRAIN AT FAILURE

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 8

FOUNDATION SECTION

JOB 72-11048

LOCATION Sta. 113 + 66 57' Rt. 6 Hwy. 401

ORIGINATED BY LJH

W.P. 166-60-0

BORING DATE May 19 & 23 - 24, 1972

COMPILED BY LJH

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger and Cone Test

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ P.C.F.	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT					WATER CONTENT %					
							20	40	60	80	100	w_p	w	w_L			
SHEAR STRENGTH P.S.F.																	
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE										
986.7	Ground Level																
0.0	Clayey silt topsoil some black organics.	~ ~ ~	1	SS	20												
980.2		~ ~ ~	2	SS	17												
6.5	Clayey silt with traces of sand and gravel. Very Stiff to Hard Brown becoming Grey		3	SS	36												
			4	SS	45												
			5	SS	53												
			6	SS	29												
			7	SS	15												
			8	SS	27												
			9	SS	30												
			10	SS	19												
			11		29												
			12	TW	PH												
944.7					13	SS	100/4"										
42.0			Sandy silt with traces of clay & gravel.														
937.7	Very Dense and Hard		14	SS	134												
49.0	End of Borehole																

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 9

FOUNDATION SECTION

JOB 72-11048 LOCATION Sta. 113 + 13 92' Rt. 0 Hwy. 401

ORIGINATED BY LJH

W.P. 166-60-0

BORING DATE May 19 & 23, 1972

COMPILED BY LJH

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger and Cone Test

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT					WATER CONTENT %				
							20	40	60	80	100	w_p	w	w_L		
SHEAR STRENGTH P.S.F.																
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE									
983.0	Ground Level															
0.0	Clayey silt with some sand and traces of gravel.		1	SS	36	980										
			2	SS	41											
			3	SS	30											
			4	SS	19											
	Hard to Very Stiff		5	SS	18	970										
			6	SS	18											
	Brown becoming Grey		7	SS	21											
			8	SS	25	960										
955.5			9	SS	27											
27.5	Sandy silt with some clay and gravel.		10	SS	31	950										
			11	SS	100/5"											
	Compact to Very Dense		12	SS	100/5"	940										
			13	SS	101/3"											
	Grey															
929.0			14	SS	100/4"	930										
54.0	End of Borehole															

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 10

FOUNDATION SECTION

JOB 72-11048

LOCATION Sta. 114 + 04 89' Rt. 0 Hwy. 401

ORIGINATED BY LJH

W.P. 166-60-0

BORING DATE May 19, 1972

COMPILED BY LJH

DATUM Geodetic

BOREHOLE TYPE Dynamic Cone Test

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — w_L PLASTIC LIMIT — w_p WATER CONTENT — w			BULK DENSITY γ	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT 20 40 60 80 100					SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE				
982.1	Ground Level					980										
0.0																
971.5																
10.6	End of Cone Test					970										

ABBREVIATIONS USED IN THIS REPORT

SOIL PROPERTIES

γ	UNIT WEIGHT OF SOIL (BULK DENSITY)
γ_s	UNIT WEIGHT OF SOLID PARTICLES
γ_w	UNIT WEIGHT OF WATER
γ_d	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
γ'	UNIT WEIGHT OF SUBMERGED SOIL
G	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
e	VOID RATIO
n	POROSITY
w	WATER CONTENT
S_r	DEGREE OF SATURATION
w_L	LIQUID LIMIT
w_p	PLASTIC LIMIT
I_p	PLASTICITY INDEX
s	SHRINKAGE LIMIT
I_L	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
I_c	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
e_{max}	VOID RATIO IN LOOSEST STATE
e_{min}	VOID RATIO IN DENSEST STATE
I_D	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY D_r IS ALSO USED
h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
k	COEFFICIENT OF PERMEABILITY
j	SEEPAGE FORCE PER UNIT VOLUME
m_v	COEFFICIENT OF VOLUME CHANGE = $\frac{-\Delta e}{(1+e)\Delta\sigma'}$
c_v	COEFFICIENT OF CONSOLIDATION
C_c	COMPRESSION INDEX = $\frac{\Delta e}{\Delta \log_{10} \sigma'}$
T_v	TIME FACTOR = $\frac{c_v t}{d^2}$ (d, DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
τ_f	SHEAR STRENGTH
c'	EFFECTIVE COHESION INTERCEPT
ϕ'	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
c_u	APPARENT COHESION
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
μ	COEFFICIENT OF FRICTION
S_t	SENSITIVITY

GENERAL

π	= 3.1416
e	BASE OF NATURAL LOGARITHMS 2.7183
$\log_e a$ OR $\ln a$	NATURAL LOGARITHM OF a
$\log_{10} a$ OR $\log a$	LOGARITHM OF a TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
W	WEIGHT
M	MOMENT
F	FACTOR OF SAFETY

STRESS AND STRAIN

u	PORE PRESSURE
σ	NORMAL STRESS
σ'	NORMAL EFFECTIVE STRESS ($\bar{\sigma}$ IS ALSO USED)
τ	SHEAR STRESS
ϵ	LINEAR STRAIN
γ	SHEAR STRAIN
ν	POISSON'S RATIO (μ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNG'S MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
η	COEFFICIENT OF VISCOSITY

EARTH PRESSURE

d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_0	COEFFICIENT OF EARTH PRESSURE AT REST

FOUNDATIONS

B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY, DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY
k_s	MODULUS OF SUBGRADE REACTION

SLOPES

H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
β	ANGLE OF SLOPE TO HORIZONTAL

ABBREVIATIONS USED IN THIS REPORT

PENETRATION RESISTANCE

STANDARD PENETRATION RESISTANCE 'N' :- THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE :- THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL, THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW.

DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS :-

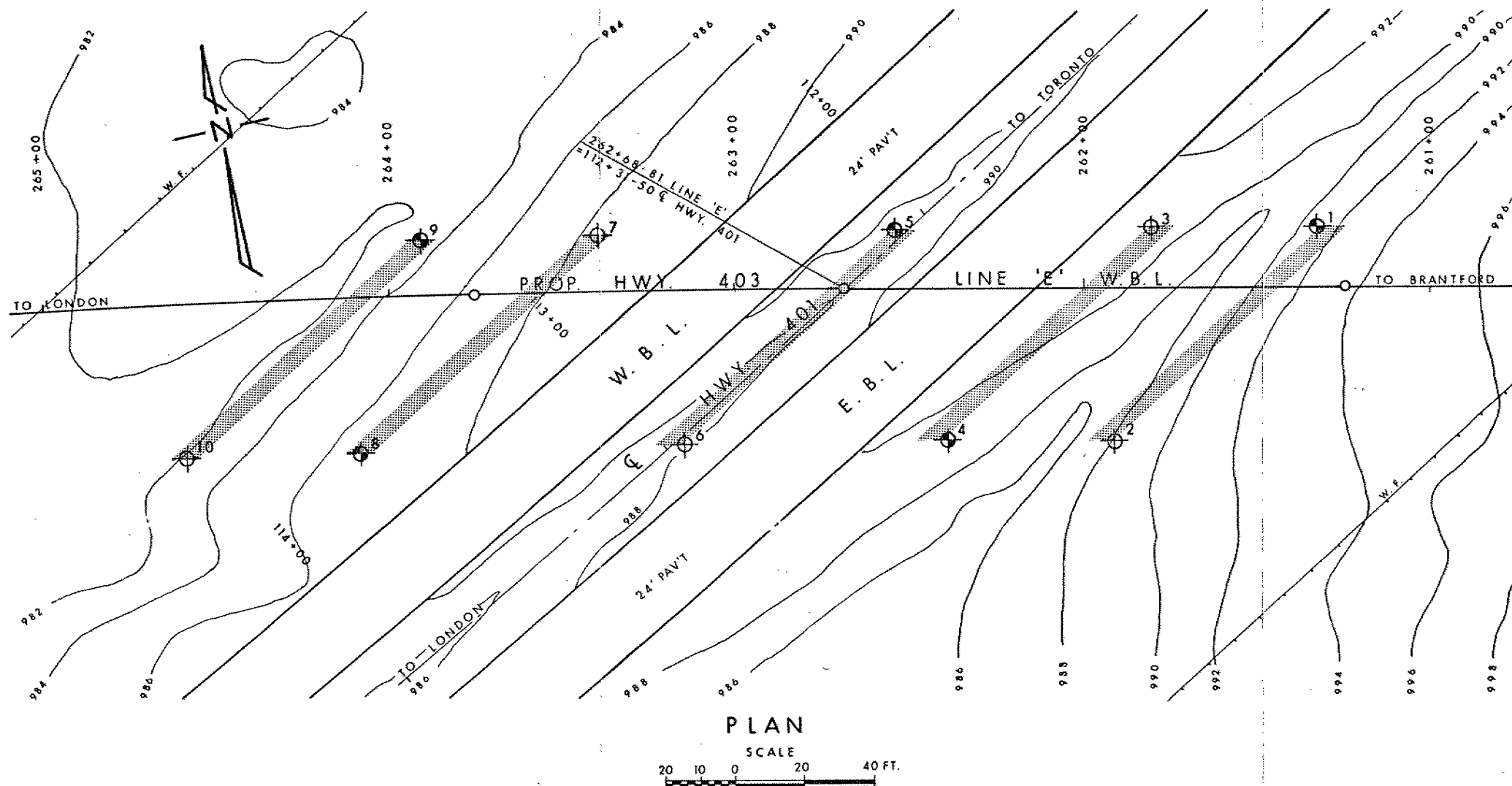
<u>CONSISTENCY</u>	<u>'N' BLOWS / FT.</u>	<u>c LB. / SQ. FT.</u>	<u>DENSENESS</u>	<u>'N' BLOWS / FT.</u>
VERY SOFT	0 - 2	0 - 250	VERY LOOSE	0 - 4
SOFT	2 - 4	250 - 500	LOOSE	4 - 10
FIRM	4 - 8	500 - 1000	COMPACT	10 - 30
STIFF	8 - 15	1000 - 2000	DENSE	30 - 50
VERY STIFF	15 - 30	2000 - 4000	VERY DENSE	> 50
HARD	> 30	> 4000		

TYPE OF SAMPLE

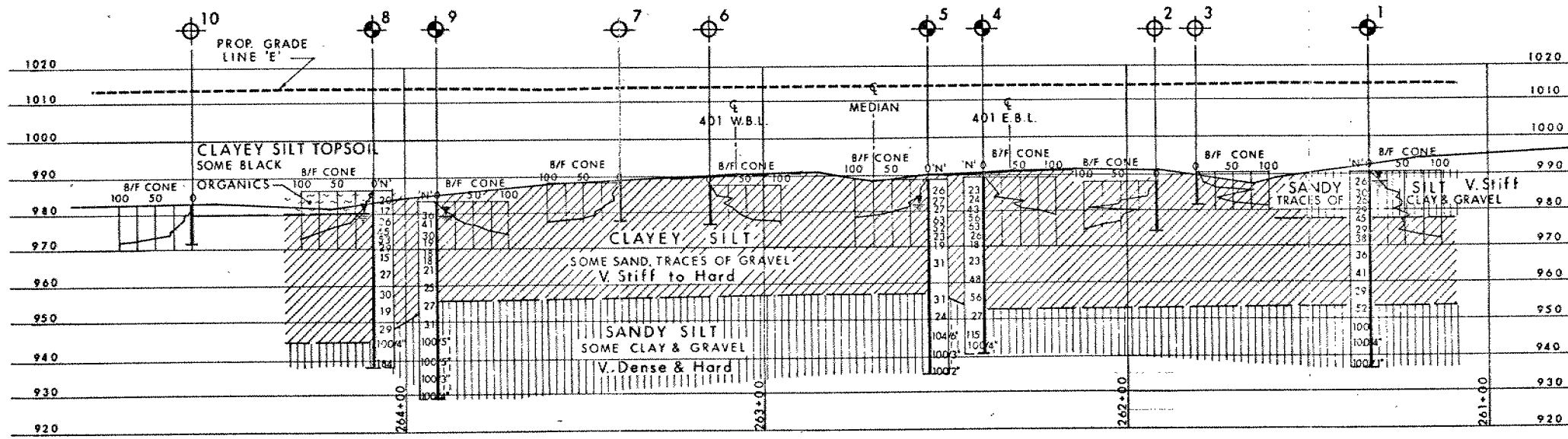
S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.B.	SCRAPER BUCKET SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE
S.T.	SLOTTED TUBE SAMPLE		
	P.H. SAMPLE ADVANCED HYDRAULICALLY		
	P.M. SAMPLE ADVANCED MANUALLY		

SOIL TESTS

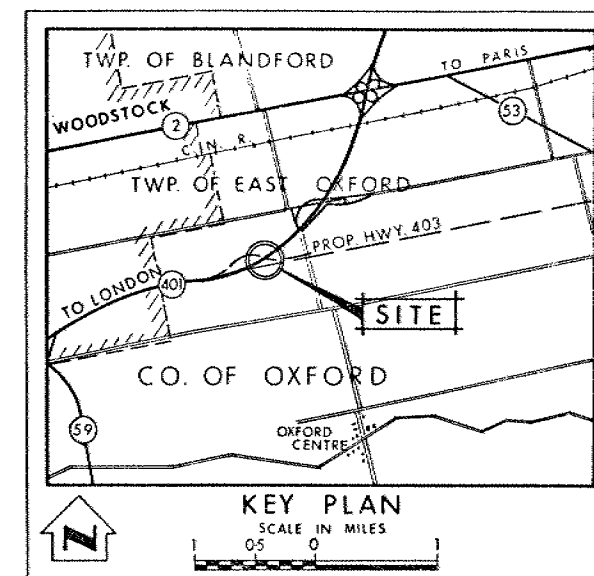
Qu	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
Q	UNDRAINED TRIAXIAL	F.V.	FIELD VANE
Qcu	CONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
Qd	DRAINED TRIAXIAL	S	SENSITIVITY



PLAN



PROFILE



LEGEND

- Bore Hole
- Cone Penetration Test
- Bore Hole & Cone Test
- Water Levels established at time of field investigation, MAY 1972
- Water Level not established in Borehole No. 4

NO.	ELEVATION	STATION	OFFSET
1	990.6	111+19	80' LT.
2	988.2	112+02	85' LT.
3	990.4	111+54	47' LT.
4	989.3	112+38	53' LT.
5	989.0	112+08	2' LT.
6	987.5	112+94	2' LT.
7	988.4	112+73	58' RT.
8	986.7	113+66	57' RT.
9	983.0	113+13	92' RT.
10	982.1	114+04	89' RT.

HWY 401

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

MINISTRY OF TRANSPORTATION & COMMUNICATIONS
DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

HIGHWAY NO. 401

HIGHWAY NO. 403 PROP. LINE 'E' DIST. NO. 4
CO. OXFORD
TWP. EAST OXFORD LOT 13 CON. 2

BORE HOLE LOCATIONS & SOIL STRATA

SUBMD P.K.	CHECKED	W.P. NO. 166-60-0	DRAWING NO.
DRAWN O.L.J.	CHECKED	JOB NO. 72-11048	72-11048A
DATE 11 AUG. 1972	SITE NO.	BRIDGE DRAWING NO.	
APPROVED	CONT. NO.		

ENGINEERING MATERIALS OFFICE
PAVEMENT & FOUNDATION DESIGN SECTION

WP 166-60-01

DIST 2

HWY 403

STR SITE 23-89-311

Hwy. 401 Interchange, (Hwy. 403 W.B.L.)

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FOUNDATION INVESTIGATION REPORT

For

W.P. 166-60-01, Site 23-89-311

Hwy. 401 Interchange, (Hwy. 403 W.B.L.)

Hwy. 403, District 2, London

INTRODUCTION:

This report summarizes the results of the foundation investigation required for the proposed structure and approach embankments at this site.

The fieldwork was conducted during the period from 82 07 21 - 27 utilizing a continuous-flight auger machine equipped with 82 mm I.D. hollow-stem augers.

This work consisted of 5 sampled boreholes/dynamic cone penetration tests.

SITE DESCRIPTION

The site is located east of Co. Rd. 15 along Hwy. 401 at Woodstock (Lot 13, Con. II, Twp. Norwich, Geog. Twp. (East) Oxford, County of Oxford).

Physiographically, the site is located in the Oxford Till Plain.

SUBSURFACE CONDITIONS

General

The Record of Borehole Sheets (Appendix) illustrate the conditions at the borehole locations. The location and elevations of the boreholes, and a stratigraphical profile based on the borehole data are shown on Drawing No. 1666001-A.

The overburden at this site is composed of till. A predominantly cohesive silty clay till overlies a predominantly non-cohesive sandy silt to silty sand till. The boundary between these two general soil types dips gradually towards the south (from elev. 290.1 m at BH #1 to elev. 284.7 m at BH #5).

Silty Clay (CL), Some Sand, Trace Gravel

This firm to hard till material extends from the surface for depths ranging from 10.1 m at BH #1 to 21.3 m at BH #5. The deposit is generally silty clay of low plasticity containing some sand and traces of gravel. The sand content generally increases with depth especially at BH #1, #2 and #3. Occasional layers of dense silty sand were encountered within this deposit at BH #1 and BH #4, generally between elev. 300 and elev. 298.

Physical properties of the cohesive portion of this material, as determined from field and laboratory tests, are summarized below:

	<u>Range</u>	<u>Average</u>	<u>Median</u>
Natural Water Content (w) %	8.0-14.5%	11.3%	N/A
Liquid Limit (W _L) %	14.0-26.0%	20.0%	N/A
Plastic Limit (W _p) %	11.0-15.0%	13.0%	N/A

Generally the material did not fail during field vane shear testing, indicating undisturbed shear strengths in excess of 107 kPa. A field vane shear strength value of 34.5 kPa, obtained near elev. 298 m at BH #3, was considered to be non-representative of the general deposit. Shear strength values from unconfined compression tests of similar material in the immediate vicinity of this site led to the selection of 150 kPa as the average shear strength for the silty clay till deposit.

Figure 1 illustrates a typical grain size distribution for the cohesive portion of this deposit.

Sandy Silt to Silty Sand, Some Gravel, Trace Clay

This very dense till deposit underlies the silty clay till across the entire site. As indicated in Drawing No. 1666001-A, occasional layers of cohesive silty clay were encountered between elev. 286 m and elev. 282 m at BH #1 and BH #3. Occasional boulders were encountered while augering within this deposit. The natural water content of the non-cohesive portion of this deposit ranged from 6.0 - 10.5%.

Figure 2 illustrates a typical grain size distribution for the non-cohesive portion of this deposit.

Groundwater

The groundwater elevation was estimated at 298 m. This estimate was based on field observations, data from previous foundation investigations in the immediate vicinity, and well records.

DISCUSSION AND RECOMMENDATIONS

A grade separation is proposed so that the west-bound lanes of Hwy. 403 will overpass Hwy. 401. In order to establish the proposed profile grade of Hwy. 403, approach fills up to 10± m high will be required. A four-span structure is proposed.

General Recommendations (Applicable To All Alternatives)

- No stability problems are anticipated for the proposed embankment heights with slopes of 2:1 or flatter.
- Total settlements under the embankments will be less than 75 mm, 50% of which should occur during construction. Total settlement for the recommended footing foundation alternatives will be less than 25 mm. The resulting differential settlements will be less than 25 mm. The structure should be designed to accommodate the anticipated settlements.
- Earth pressure acting on abutments and retaining walls should be computed as per Subsection 6.6.1.2.2 of the O.H.B.D.C. assuming a yielding foundation with $k_a = 0.33$ for granular backfill
- For frost protection, cover should be greater than 1.2 m
- Dewatering is not anticipated to be a major problem because of the impermeable nature of the foundation soil

Foundation Alternatives

The foundation alternative which leads to the least expensive design should be adopted.

Alternative 1 - Spread Footings on Silty Clay

The entire structure may be supported on spread footings founded at or below the following elevations:

<u>Station (Hwy. 403 Chainage)</u>	<u>Elevation</u>
Station 11 + 257	297.6
Station 11 + 278	298.6
Station 11 + 320	297.5
Station 11 + 354	300.1
Station 11 + 371	302.0

For resistance to lateral forces, the adhesion between the base of the footings and the foundation soil = 60 kPa.

Cover the foundation soil with a 15 cm pad of mass concrete within 18 hours of exposure.

The following design values are recommended:

- net safe bearing pressure = 300 kPa

and for purposes of the O.H.B.D.C.:

- Factored Bearing Capacity at U.L.S. = 450 kPa
- Bearing Capacity at S.L.S. Type II = 300 kPa

Alternative 2 - Perched Footings on Compacted Fill

The abutments may be supported on perched abutments on compacted granular fill. Refer to the enclosed Figure 2 for design details.

All loose or soft material beneath the approach embankment in the vicinity of the abutment locations should be removed.

For computing sliding resistance between the base of the concrete footing and the compacted fill, the friction coefficient = 0.6.

The following design values are recommended:

- net safe bearing capacity = 340 kPa

and for purposes of the O.H.B.D.C.:

- Factored Bearing Capacity at U.L.S. = 600 kPa
- Bearing Capacity at S.L.S. Type II = 340 kPa

Alternative 3 - Steel H-Piles in Overburden

The entire structure may be supported on Steel H-Piles equipped with reinforced tips and driven in accordance with M.T.C. Standards SS103-10 or SS103-11. For calculation purposes the following values are recommended:

<u>Pile Type</u>	<u>Ultimate Capacity</u>
310 HP 110	3000 kN
310 HP 79	2150 kN

For estimation purposes, it may be assumed that the recommended pile capacities will be achieved at the following elevations:

<u>Station (Hwy. 403 Chainage)</u>	<u>Elevation</u>
Station 11 + 257	287
Station 11 + 278	285
Station 11 + 320	285
Station 11 + 354	283
Station 11 + 371	281

If desired, the abutment footings (supported on Steel H-Piles) may be perched within the embankment fill. In this case, to facilitate pile driving, particle sizes in the fill immediately beneath the pile locations should not exceed 75 mm.

The following design values are recommended:

<u>Pile Type</u>	<u>Safe Capacity</u>
310 HP 110	1000 kN
310 HP 79	720 kN

and for the purposes of the O.H.B.D.C.:

<u>Pile Type</u>	<u>Factored Capacity at U.L.S.</u>	<u>Capacity at S.L.S. Type</u>
310 HP 110	1350 kN	1000 kN
310 HP 79	970 kN	720 kN

Alternative 4 - Combination of Previous Alternatives

If desired, the previous alternatives may be combined so that different alternatives are employed at different footing locations.

For example, the centre pier footing may be supported on Steel H-piles while the abutment footings are perched on compacted granular fill.

MISCELLANEOUS

The fieldwork for this project was carried out under the supervision of Mr. B. Yiu (student field technician). The report was written by Mr. D. H. Dundas, Project Foundations Engineer, and reviewed by Mr. K. G. Selby, Senior Foundations Engineer. The equipment used was owned and operated by Atcost Soil Drilling Inc.



D. H. Dundas

D. H. Dundas, P. Eng.
Project Foundations Engineer

K. G. Selby

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

A P P E N D I X

RECORD OF BOREHOLE No 1

METRIC

W P 166-60-01 LOCATION Sta. 11 + 257 & W.B.L. ORIGINATED BY BY
DIST 2 HWY 403/401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY DD
DATUM Geodetic DATE 82 07 22 CHECKED BY DD

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
300.2	Ground Surface															GR SA SI CL
0.0	occ. layers of Silty Sand, Compact		1	SS	16	**										5 42 43 10
			2	SS	17											9 40 37 14
	Silty Clay (CL)		3	SS	29											
	Some Sand		4	SS	24											
	Trace Gravel		5	SS	11											
	Stiff to Very Stiff (Till)		6	SS	10											
	with Sand		7	SS	20											
			8	SS	18											5 43 38 14
290.1	Sandy Silt to Silty Sand		9	SS	100/	24 cm										19 37 37 7
	Some Gravel		10	SS	100/	22 cm										15 37 42 6
	Trace Clay		11	SS	100/	22 cm										
	Very Dense (Till)		12	SS	100/	18 cm										
	occ. layers of Silty Clay (CL) Hard		13	SS	100/	24 cm										
281.9			14	SS	100/	19 cm										
18.3	End of Borehole															*Cu > 107kPa
	** Stabilized ground water level estimated from well records															

RECORD OF BOREHOLE No 2

METRIC

W P 166-60-01 LOCATION Sta. 11 + 278 & W.B.L. ORIGINATED BY HY
DIST 2 HWY 403/401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY DP
DATUM Geodetic DATE 82 07 23 CHECKED BY DP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
300.7	Ground Surface																
0.0	Silty Clay (CL)																
	Some Sand		1	SS	13												
	Trace Gravel		2	SS	18												
	Stiff to Hard		3	SS	33												
	(Till)		4	SS	34												
			5	SS	29												
			6	SS	10												
			7	SS	20												
	with Sand		8	SS	15												
			9	SS	16												
289.1																	
11.6	Sandy Silt to Silty Sand, Some Gravel		10	SS	1007	18 cm											
	Trace Clay																
	Very Dense (Till)		11	SS	1007	17 cm											
286.7																	
14.0	End of Borehole																
	** Stabilized ground water level estimated from well records																*C _u > 107kPa

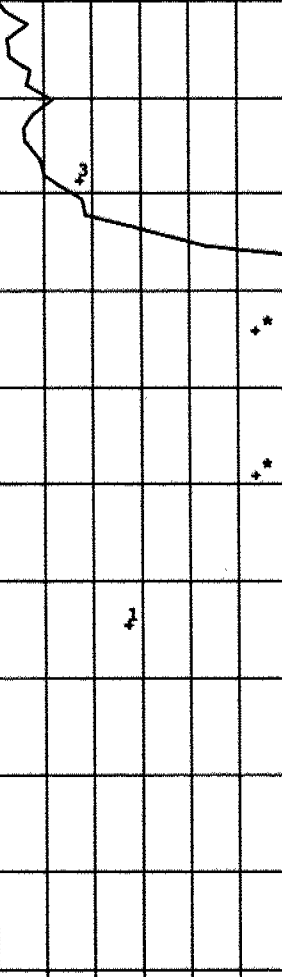
+3, x⁵: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL BAWLOCATION

RECORD OF BOREHOLE No 3

METRIC

W P 166-60-01 LOCATION Sta. 11 + 320 ± W.B.L. ORIGINATED BY BY
DIST 2 HWY 403/401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY DD
DATUM Geodetic DATE 82 07 21 CHECKED BY DD

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100					
302.1	Ground Surface												GR SA SI CL
0.0	Silty Clay (CL) Some Sand Trace Gravel Firm to Hard (Till)		1	SS	16	** ↓					4 11 55 30		
			2	SS	18								
			3	SS	15								
			4	SS	5								
			5	SS	22								
			6	SS	24								
			7	SS	17								
			8	SS	20								
			9	SS	21								
			10	SS	12								
289.0	with Sand					15 cm						27 33 36 4	
13.1	Sandy Silt to Silty Sand Some Gravel Trace Clay Very Dense (Till) occ. layers of Silty Clay (CL) Hard		11	SS	100/								
			12	SS	100								
			13	SS	100								
280.3			14	SS	100								
21.8	End of Borehole ** Stabilized ground water level estimated from well records												*Cu > 107kPa

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10



Ministry of
Transportation and
Communications

RECORD OF BOREHOLE No 4

METRIC

W P 166-60-01

LOCATION Sta. 11 + 354 @ W.B.L.

ORIGINATED BY BY

DIST 2 HWY 403/401

BOREHOLE TYPE Hollow Stem Auger

COMPILED BY DD

DATUM Geodetic

DATE 82 07 27

CHECKED BY DD

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	N' VALUES			SHEAR STRENGTH kPa								
							20	40	60	80	100	10	20	30		
301.9	Ground Surface															
0.0			1	SS	31											
			2	SS	29											
	occ. layers of Silty Sand, Compact		3	SS	19											
			4	SS	15											
	Silty Clay (CL)															
	Some Sand		5	SS	21											
	Trace Gravel															
	Stiff to Hard (Till)		6	SS	26											
			7	SS	29											
			8	SS	36											
			9	SS	47											
			10	SS	32											
288.0			11	SS	57											
13.9	Sandy Silt to Silty Sand															
	Some Gravel		12	SS	100											4 30 56 10
	Trace Clay															
	Very Dense (Till)		13	SS	100											9 43 42 6
284.7	End of Borehole															*C _u > 107kPa
17.2	** Stabilized ground water level estimated from well records															

+3, x⁵: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION



Ministry of
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Communications
Ontario

RECORD OF BOREHOLE No 5

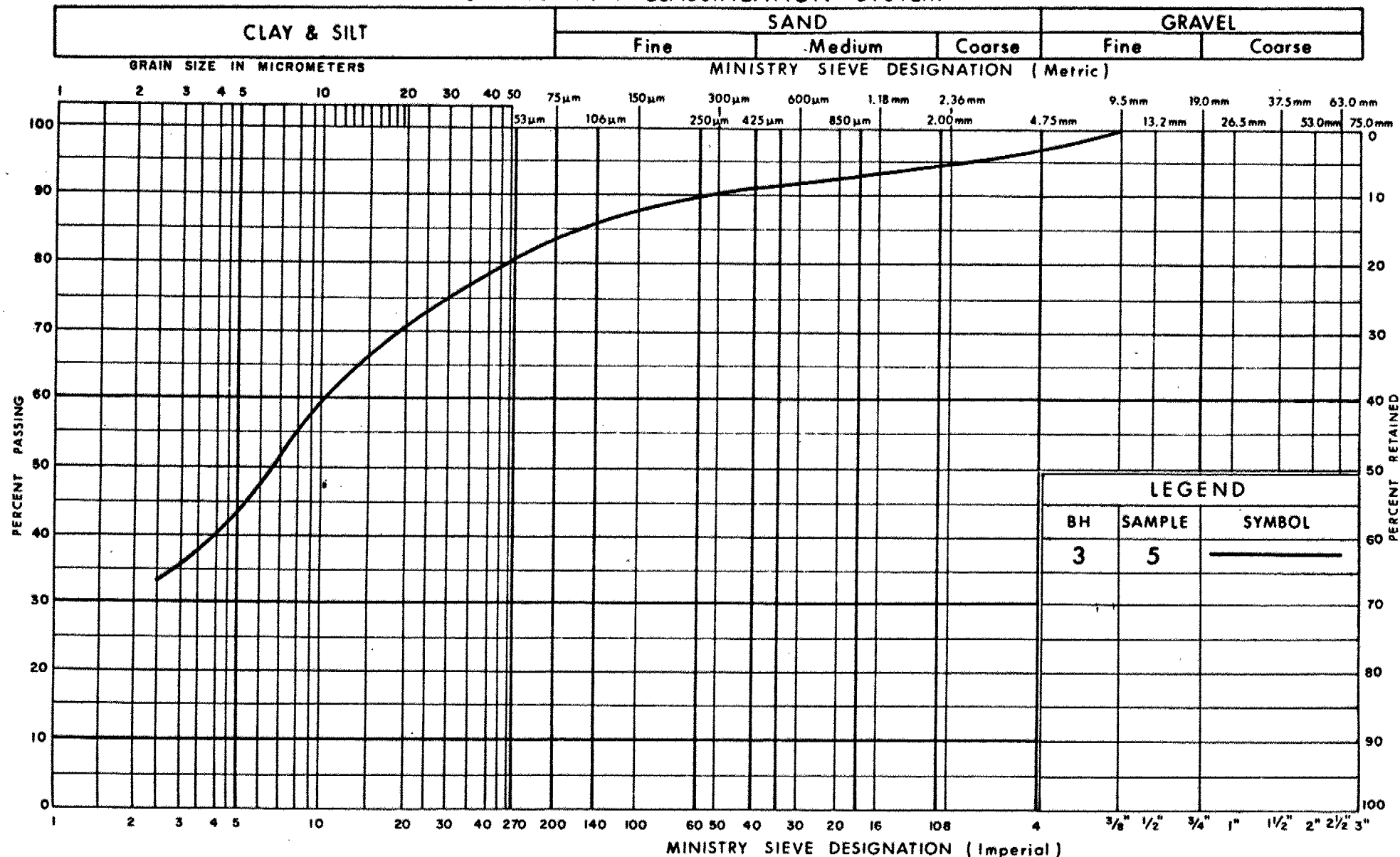
METRIC

W P 166-60-01 LOCATION Sta. 11 + 375, 5.0 m Rt. of W.B.L. ORIGINATED BY BY
DIST 2 HWY 403/401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY DD
DATUM Geodetic DATE 82 07 23-26 CHECKED BY DD

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE 20 40 60 80 100	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE						
306.0	Ground Surface									
0.0	Silty Clay (CL) Some Sand Trace Gravel Stiff to Hard (Till)		1	SS	29					
			2	SS	37					
			3	SS	29					
			4	SS	15					
			5	SS	19					
			6	SS	17					
			7	SS	17					
			8	SS	27					
			9	SS	19					
			10	SS	25					
			11	SS	27					
			12	SS	29					
			13	SS	31					
284.7			14	SS	100	20 cm				
21.3	Sandy Silt to Silty Sand Some Gravel, Trace Clay Very Dense (Till)		15	SS	100	28 cm				
282.5	Probable Boulder Refusal to Auger End of Borehole ** Stabilized ground water level estimated from well records									*Cu > 107 kPa

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

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

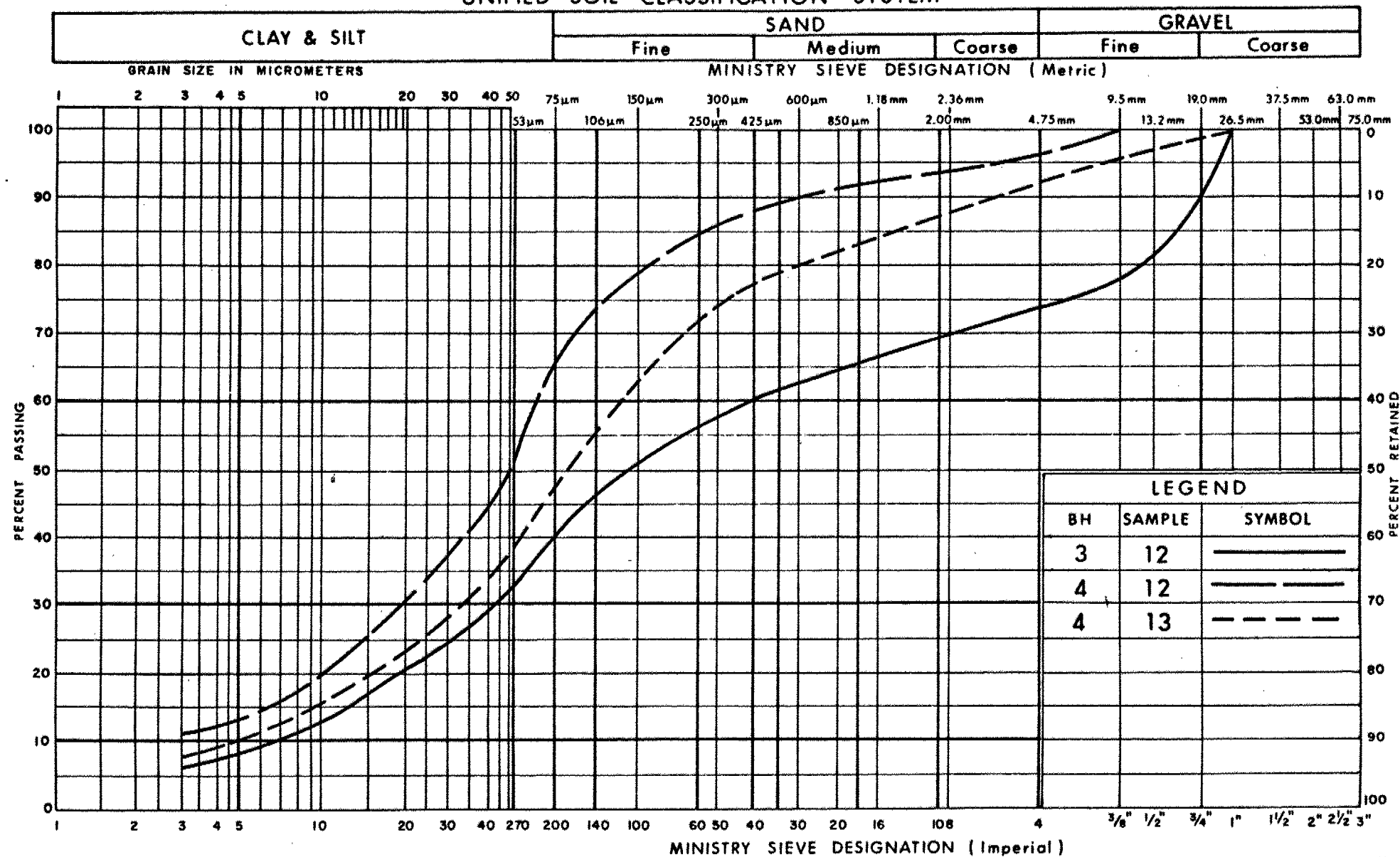
 Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION
SILTY CLAY (Till)
SOME SAND TRACE GRAVEL

FIG No 1

W P 166-60-01

UNIFIED SOIL CLASSIFICATION SYSTEM



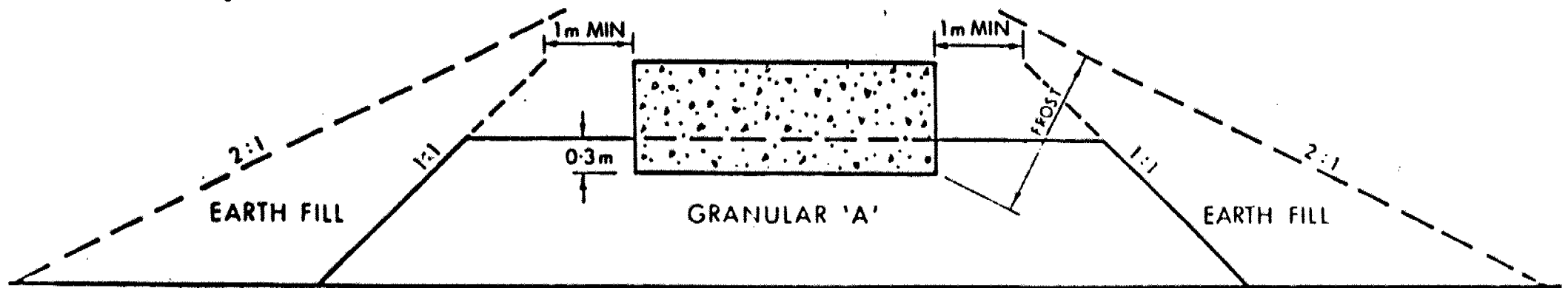
Ministry of
Transportation and
Communications

GRAIN SIZE DISTRIBUTION
SANDY SILT TO SILTY SAND
SOME GRAVEL TRACE CLAY

FIG No 2

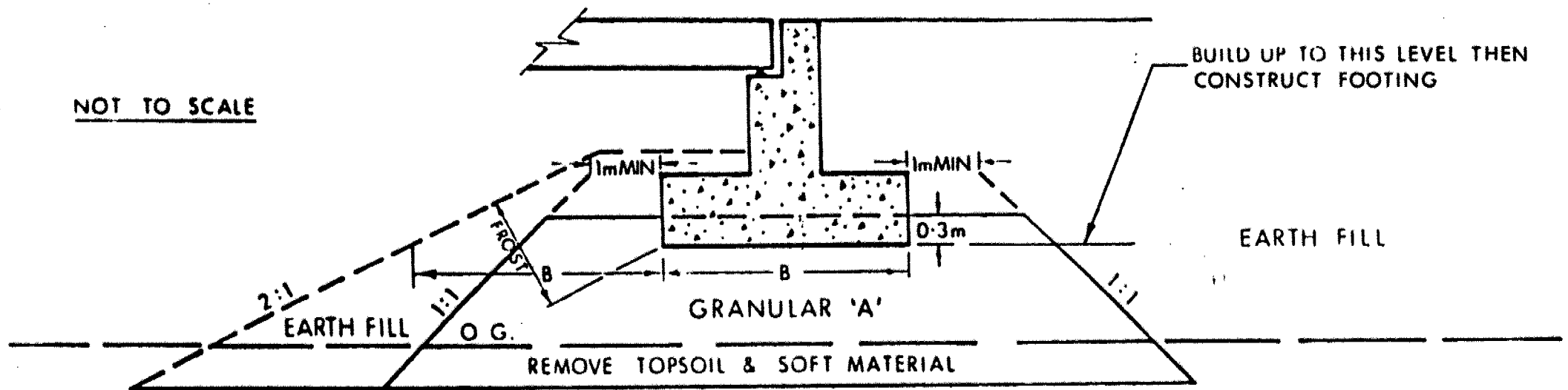
W P 166-60-01

ABUTMENT ON COMPACTED FILL SHOWING GRANULAR 'A' CORE



X SECTION

NOT TO SCALE



LONGITUDINAL SECTION

NOTES:

- 1 - REMOVE TOPSOIL &/OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' & EARTH FILL.
- 2 - PLACE GRANULAR 'A' & EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO CURRENT M.T.C. STANDARDS.
- 3 - CONSTRUCT CONCRETE FOOTING
- 4 - PLACE REMAINDER OF GRANULAR 'A' & EARTH FILL AS REQUIRED

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	>200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

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

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	>50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

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

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

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

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

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	>3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{v0}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kn/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kn/m^3	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kn/m^3	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	kn/m^3	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kn/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kn/m^2	SEEPAGE FORCE
γ'	kn/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES.

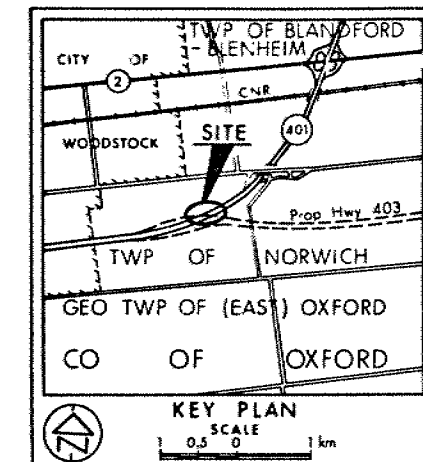
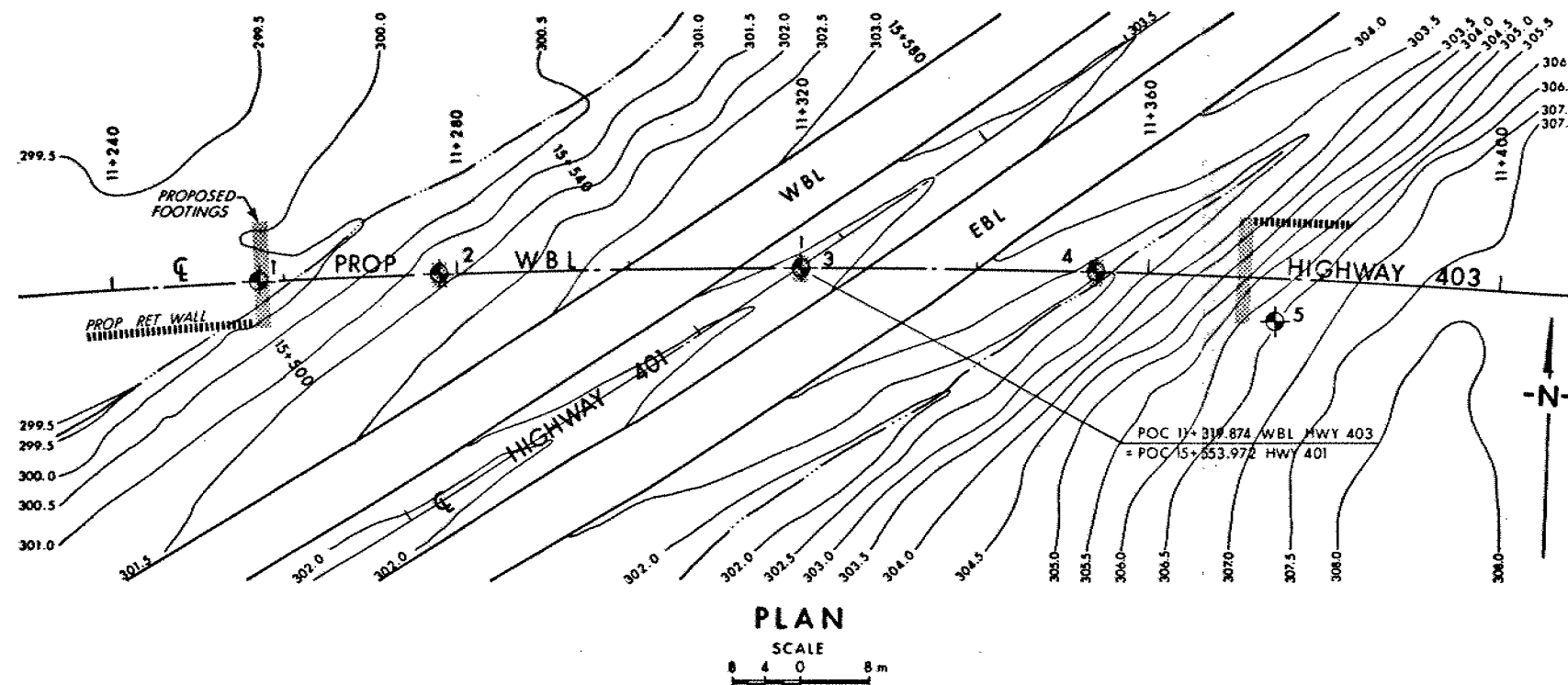
CONT No
WP No 166-60-01



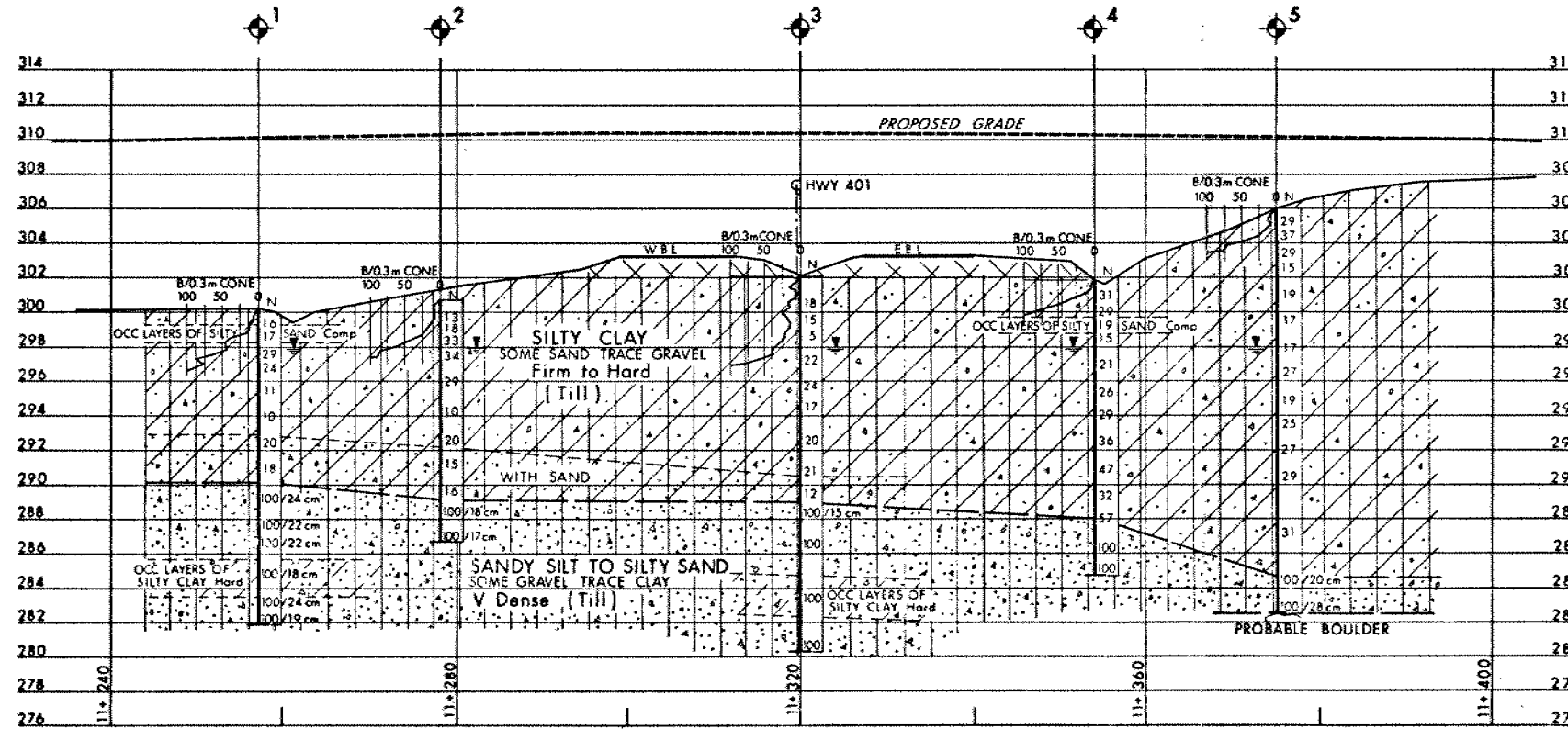
HWY 401 INTERCH O'PASS

SHEET

BORE HOLE LOCATIONS & SOIL STRATA



- LEGEND**
- ◆ Bore Hole
 - ⊕ Dynamic Cone Penetration Test (Cone)
 - ⊕ Bore Hole & Cone
 - N Blows/0.3m (Std Pen Test, 475 J/blow)
 - CONE Blows/0.3m (60° Cone, 475 J/blow)
 - W.L. at time of investigation 82.07
 - NOTE: Stabilized Ground Water Level Estimated from Well Records



No	ELEVATION	STATION	OFFSET
1	300.2	11+257	CL
2	300.7	11+278	CL
3	302.1	11+320	CL
4	301.9	11+354	CL
5	306.0	11+375	5 m RT

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

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REV.	DATE	BY	DESCRIPTION

Geocres No 40P2-40

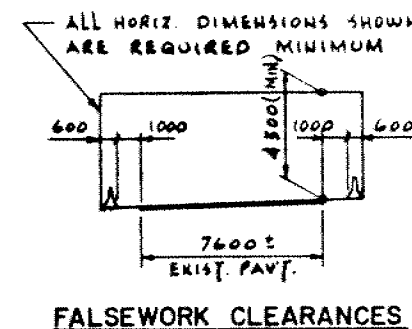
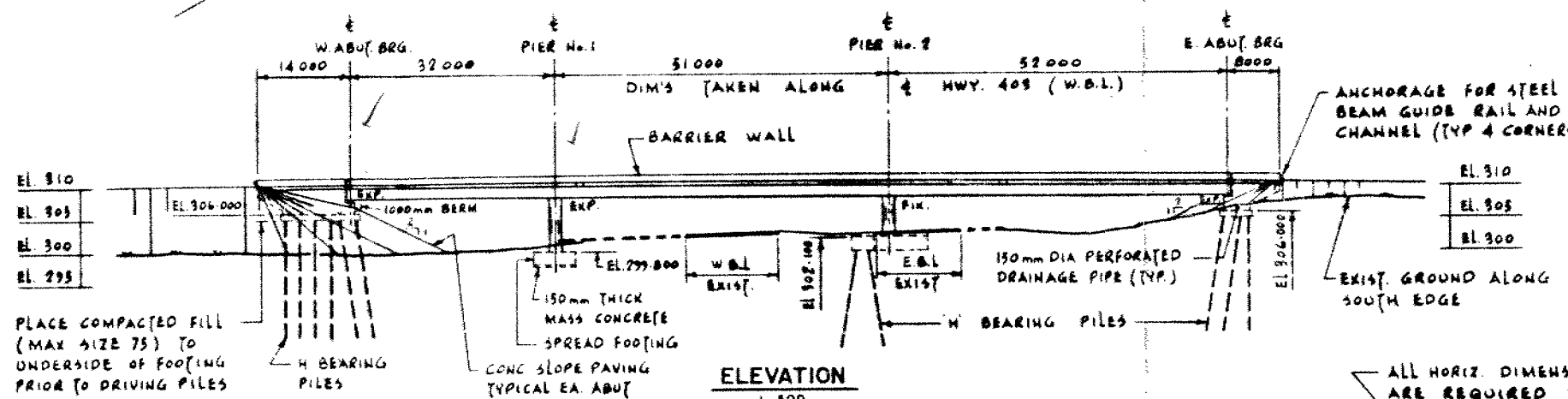
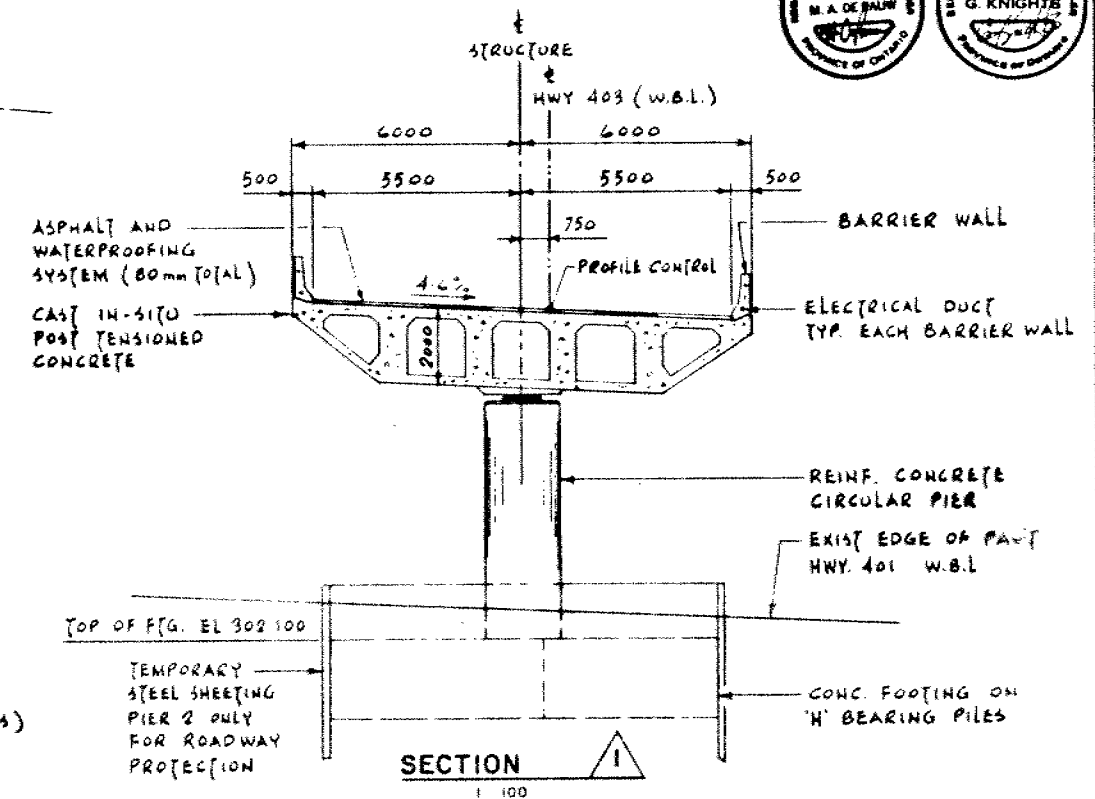
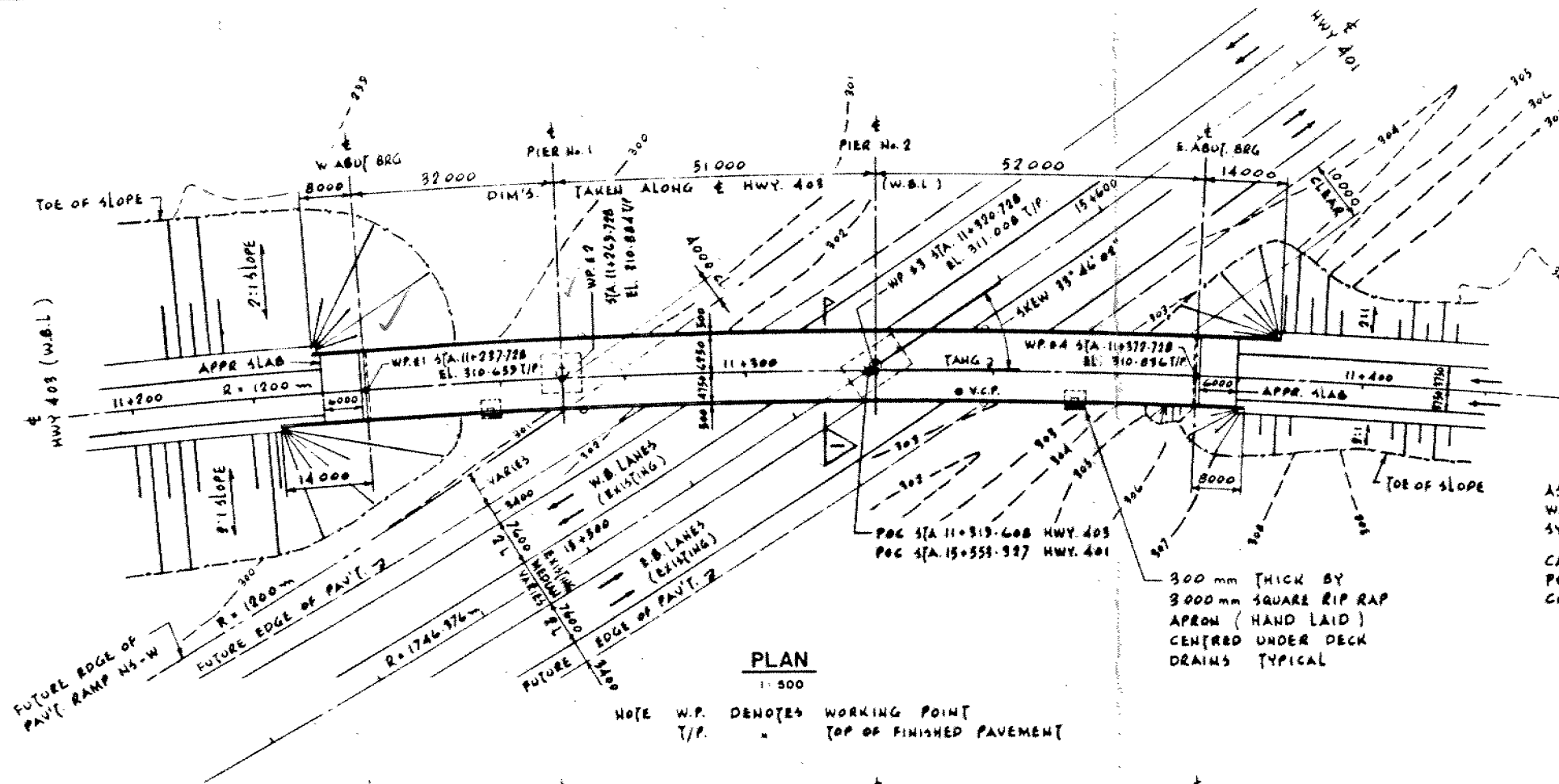
HWY No 403 WBL	DIST 2
SUBM'D D.D. CHECKED	DATE 82.11.12
DRAWN SO CHECKED	DATE 82.11.12

1666001-A



METRIC

DIMENSIONS ARE IN MILLIMETRES
UNLESS OTHERWISE SHOWN.
ELEVATIONS, COORDINATES, CURVE
AND ALIGNMENT DATA ARE IN METRES.
STATIONS ARE IN KILOMETRES + METRES.



LIST OF DRAWINGS

- 1 GENERAL ARRANGEMENT
- 2 BOREHOLE LOCATION & SOIL STRATA
- 3 FOUNDATION LAYOUT
- 4 FOUNDATION REINFORCEMENT
- 5 WEST ABUTMENT LAYOUT
- 6 WEST ABUTMENT REINFORCEMENT
- 7 EAST ABUTMENT LAYOUT
- 8 EAST ABUTMENT REINFORCEMENT
- 9 PIERS AND BEARINGS
- 10 DECK LAYOUT & SCREED ELEVATIONS
- 11 LONGITUDINAL CABLE DETAILS I
- 12 LONGITUDINAL CABLE DETAILS II
- 13 TRANSVERSE CABLES I
- 14 TRANSVERSE CABLES II
- 15 DECK REINFORCEMENT I
- 16 DECK REINFORCEMENT II
- 17 DECK REINFORCEMENT III
- 18 EXPANSION JOINTS
- 19 BARRIER WALL
- 20 APPROACH SLABS
- 21 DETAILS OF CONC. SLOPE PAVING
- 22 STANDARD DETAILS
- 23 EMBEDDED ELECTRICAL I
- 24 EMBEDDED ELECTRICAL II
- 25 PILE DRIVING
- 26 BRIDGE DATE AND SITE NO
- 27 AS CONSTRUCTED ELEVATIONS AND DIMENSIONS
- 28 QUANTITIES - STRUCTURE
- 29 QUANTITIES - STRUCTURE

GENERAL NOTES

CLASS OF CONCRETE

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

FOOTINGS

100% 25	80% 20
PIERS	80% 20
ABUTMENTS AND RETAINING WALLS	80% 20
DECK TOP SLAB TOP BARS	70% 20
BOT SLAB & WEBS	40% 10
REMAINDER 70% 20 OR AS SHOWN	40% 10

ON STANDARD DRAWINGS

GRADE OF REINFORCING STEEL

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

CONSTRUCTION NOTES

THE CONTRACTOR IS RESPONSIBLE FOR FINISHING
THE BEARING SEATS DEAD LEVEL TO THE SPECIFIED
ELEVATIONS WITH A TOLERANCE OF ± 3 mm.

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

memorandum



To: J. L. Keen

Date: 83 04 19

Design Engineer (SW Region)
Structural Office
3501 Dufferin St.

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

Re: Hwy 401 Interchange
Hwy 403 Westbound
W.P. 166-60-01, Site 23-89-311
District 2, London

This section has reviewed the submitted final drawings and special provisions.

Please note that piles may be driven in accordance with Standards SS 103-10 and SS 103-11.

D. H. Dundas

D. H. DUNDAS, P.Eng.,
Project Foundation Engineer.