

DOCUMENT MICROFILMING IDENTIFICATION

GEOCRES No. 30M13-124

DIST. 6 REGION CENTRAL

W.P. No. 130-79-01(c)

CONT. No. _____

W. O. No. _____

STR. SITE No. 24-31

HWY. No. 10

LOCATION PROPOSED CULVERT EXTENSION
UNDER Hwy 10

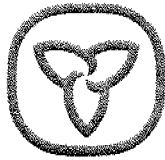
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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. _____

REMARKS: _____

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Ontario

Ministry of
Transportation and
Communications

foundation investigation and design report

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 130-79-01(c) DIST 6
HWY 10 STR SITE 24-31

Proposed Culvert Extension Under Hwy. 10
0.8 Km South of Hwy. 24

DISTRIBUTION

V.F. Boehnke (3)
G. Cautillo
J. Cullen (2)
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E.A. Joseph
I. Harrod (Cover Only)
F. Bacchus (Cover Only)
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FOUNDATION INVESTIGATION REPORT
For
Proposed Culvert Extension Under Hwy. 10
0.8 Km South of Hwy. 24
W.P. 130-79-01, Site No. 24-31
District 6, Toronto

INTRODUCTION

This report summarizes the results of a foundation investigation conducted at the aforementioned site. The proposed widening of Hwy. 10 necessitates extending both ends of an existing twin-cell concrete rigid frame, open footing culvert.

The subsurface conditions encountered at the site and recommendations pertaining to the culvert extension beneath Hwy. 10 (see Drawing No. 1307901-A) are included in the scope of this report.

SITE DESCRIPTION AND GEOLOGY

The site is located approximately 0.8 km south of Hwy. 24 on Hwy. 10. The existing culvert is an 28 m long by 8 m high by 1.8 m wide open footing culvert located underneath Hwy. 10 which will be extended both east and west to accommodate the proposed widening of Hwy. 10.

The surrounding area consists of rolling grasslands with clusters of trees. Farms and private dwellings are scattered throughout the area. The Town of Caledon is located 1 km north, and just 50 m north on the east side of Hwy. 10 is a MTO patrol yard. There are gravel pits on either side, with MGS to the east, and Armbro Land Development to the west. A creek runs perpendicular to Hwy. 10, which consists of marshy, swampy vegetation along its banks.

Physiographically, the site is located at the fringes of the physiographic regions known as the Oak Ridges moraine and the Hillsburgh Sandhills. Much of the Oak Ridges moraine for the most part are hills composed of sandy or gravelly materials, this is not always the case with some of the highest ridges formed of till which protrudes above the sands. The rough

topography, sandy materials, and flat bottomed swampy valley running through the moraine are the outstanding characteristics. Further west the sand gradually gives way to a till.

INVESTIGATION PROCEDURES

Soil data were obtained by in situ and laboratory testing conducted on selected samples. The fieldwork for the investigation was carried out between 91 07 05 and 91 07 08 and consisted of two boreholes located at the southwest and northeast corners of the proposed culvert extension.

The boreholes were advanced 9.6 m in BH 2 to 9.9 m in BH 1, below the existing ground surface. Cone penetration tests at the bottom and surface, accompanied each hole.

Track mounted CME 55 equipment employing hollow stem augering techniques was used to advance the boreholes in the overburden.

In general, disturbed subsoil samples were retrieved at 0.7 m intervals for the surficial 3.0 m and at 1.5 m intervals thereafter. All samples were identified in the field and returned to the laboratory for review.

Groundwater levels were obtained by monitoring in the open borehole throughout the duration of the field investigation. All boreholes were backfilled at the completion of the fieldwork.

Survey information related to the location and elevation of boreholes was provided by the field technician.

SUBSURFACE CONDITIONS

The subsoil conditions encountered at the site consisted of a thin top soil layer of sand with organics, trace silt and clay, ranging in thickness from 0.1 to 0.3 m.

The surficial layer is underlain by a heterogeneous mixture of silt, sand, and gravel, with cobbles and boulders (cohesionless Glacial Till) ranging in thickness from 8.3 m to 10 m or more from west to east (see BH Logs App.). This layer was compact to very dense, but generally compact to dense. This difference in density and high Standard Penetration Test 'N' values (see BH Logs App.) is considered a result of the presence of cobbles and boulders throughout the stratum.

Underlying the glacial till is a clay silt, with sand and gravel (cohesive Glacial Till). This deposit was found at 8.5 m from the surface and extending past the limits of this investigation. The consistency was hard having 'N' values of 78 and greater.

GROUNDWATER CONDITIONS

Observation of the groundwater level was carried out by measuring the water level in the open boreholes, and the water table in the creek. The groundwater level in the boreholes was found to range between elevation 404 m and 404.5 m, which corresponds to depths of 3.9 m and 2.8 m below the existing ground surface (see BH 1 and BH 2 Logs App.). The water table of the creek has an elevation of 406.9 m which would be more accurate, since the boreholes could not be left open long enough to allow water levels to sufficiently rise. These levels may fluctuate due to seasonal changes.

DISCUSSION AND RECOMMENDATIONS

It is proposed to extend the existing twin-cell culvert underneath Hwy. 10. The existing culvert is 8.0 m by 1.8 m within total length of 28 m.

The proposed extensions would be 8.0 m in length to the east and west Hwy. 10. It is understood that the proposed extension may be designed as an open culvert or closed culvert. Foundation recommendations are provided in this report for both these options.

Based on a review of the data provided to us, it is estimated that the existing culverts are founded at about elevations of 405 to 405.8 m. For the purposes of this report it is assumed that the proposed extensions would also be founded at the above elevations.

Foundation recommendations will include those for a normal closed box culvert, and a open-footing culvert, due to fishery concerns.

The following design values can be utilized for the design of the proposed culvert extensions.

	Factored Bearing Capacity at U.L.S. (kPa)	Bearing Capacity at S.L.S. Type II (kPa)	Founding Elevation (m)
Open Culvert	500 kPa	300 kPa	405.4
Closed Culvert	1500 kPa	1000 kPa	405.4

X retract
D. Dundas
Nov 9/99
maybe 2000?

The above recommendations are based on an assumed footing width of 1 m for the open culvert and a base width of 8 m for the closed culvert.

In either case the total and differential settlement will occur immediately following construction, and will be less than 25 mm, if the foundation is constructed in accordance with the recommendations provided.

To accommodate any resulting differential settlement between the existing culvert and proposed extensions, suitable connections should be provided.

CONSTRUCTION CONSIDERATIONS

The excavation, for the proposed foundation would extend to about 2 m below the existing grade, and about 1.5 m below the creek water level. Therefore in order to facilitate the construction of the proposed extension, temporary diversion of the water course could be considered.

A cofferdam, together with open oversized excavation techniques can be used, along with provision to pump water from sumps located along the perimeter of the excavation.

Alternatively, a sheet pile wall surrounding the excavation could also be used. The sheet pile would have to extend a minimum of 2.5 m below the footing elevation.

MISCELLANEOUS

The fieldwork of this investigation was carried out by P. Thase, Student Engineer, under the overall direction of B. Iyer, Senior Foundation Engineer. The equipment was owned and operated by Malones Soil Samples.

The report was written by P. Thase and reviewed and approved by B. Iyer and approved by M. Devata, Chief Foundation Engineer.



M. Michalek
M. MICHALEK, JR. FOUND. ENG.
FOR:

P. Thase
Student Engineer

M. Devata
M. Devata, P.Eng.
Chief Foundation Engineer

APPENDIX

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:

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

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

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_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 ³	SEEPAGE FORCE
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL						

Sampling intervals
are incorrect:

$2\frac{1}{2}'$ sampling to 20'

6' sampling to end of 6h

METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

PLATE No M640/38-C

CONT No

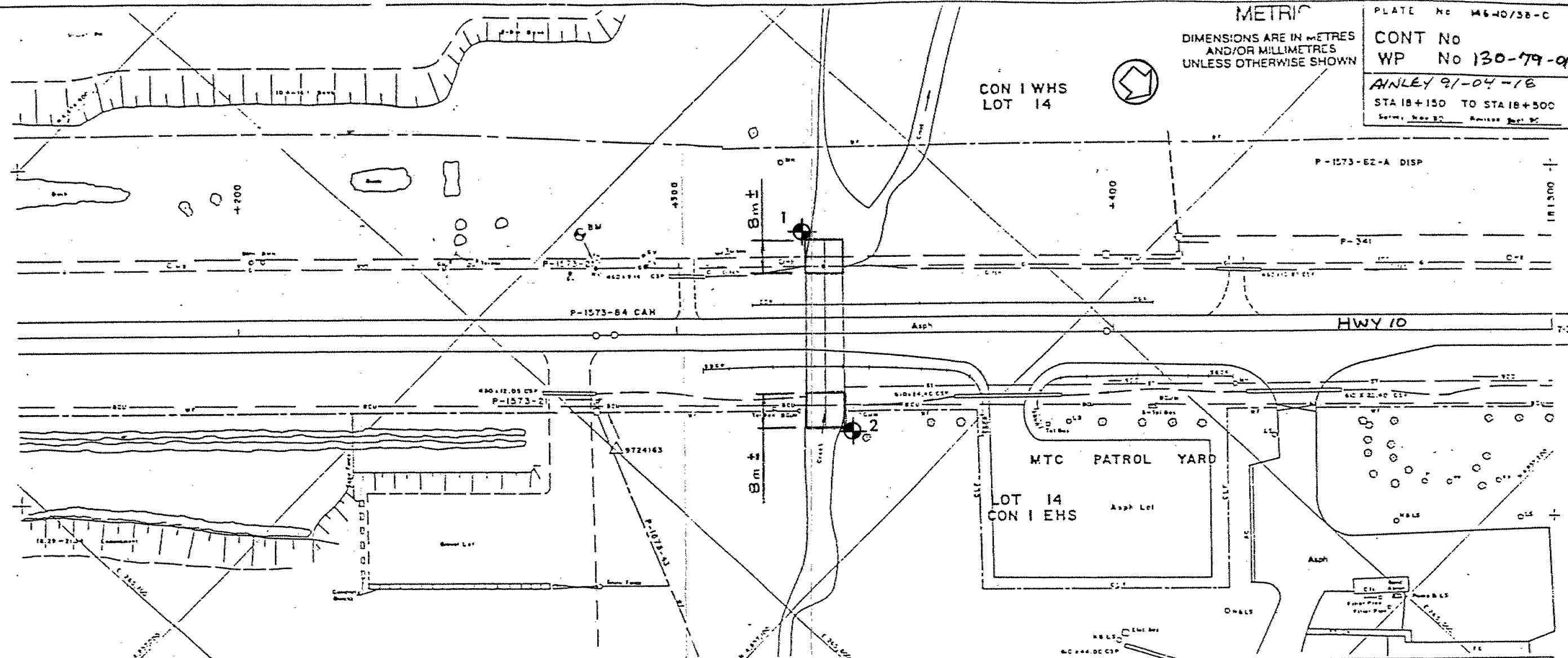
WP No 130-79-01

ANLEY 91-04-16

STA 18+150 TO STA 18+500

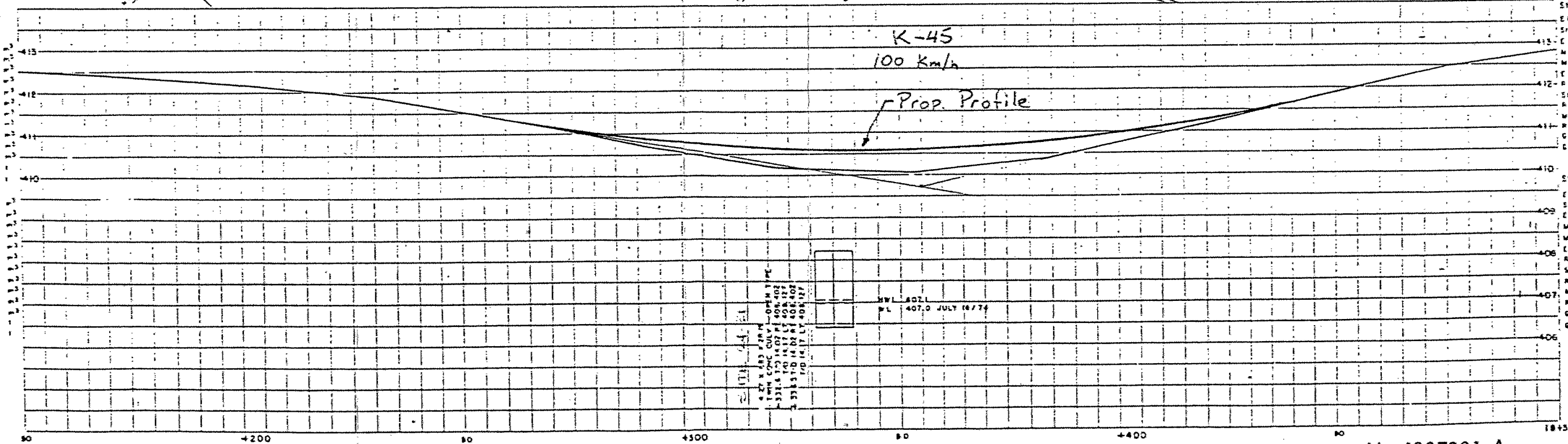
Survey: Nov 87, Release: Dec 87

CON 1 WHS
LOT 14



QUANTITIES

EC
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GSE



Dwg No 1307901-A

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

W.P. 130-79-01 LOCATION STA 18+330, 24 m. west of centerline of Hwy 10 ORIGINATED BY P.T.
DIST 6 HWY 10 BOREHOLE TYPE Hollow Stem Auger COMPILED BY P.T.
DATUM Geodetic DATE 91-07-05 CHECKED BY B.I.

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							WATER CONTENT (%)
								UNCONFINED • QUICK TRIAXIAL	+ FIELD VANE x LAB VANE						
407.9	Ground Surface												7	GR SA SI CL	
0.0	Sand with Organics, trace Silt and Clay		1	SS	6									10 55 20 15	
			2	SS	12										
			3	SS	18									54 35 6 5	
			4	SS	23										
			5	SS	22										
			6	SS	24										
	Heterogeneous mixture of Silt, Sand and Gravel, with Cobbles and Boulders (Glacial Till)		7	SS	12									65 21 12 2	
	Compact to Very Dense		8	SS	71										
			9	SS	49										
			10	SS	63										
			11	SS	45									22 70 7 1	
	Interbedded Sand layers		12	SS	20										
			13	SS	50									16 73 7 4	
399.5			14	SS	26										
8.4	Heterogeneous mixture of Clay, Silt, Sand and Gravel (Glacial Till)		15	SS	60	/3cm								15 43 25 17	
	Hard		16	SS	78										
398.1															
9.8 397.8	End of Borehole														
10.1	End of Cone Test														
	• Water level in open borehole ** Water level of Creek at time of investigation														

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

W.P. 130-79-01 LOCATION STA 18+341. 23 m. east of centerline of Hwy 10 ORIGINATED BY P.T.
DIST 5 HWY 10 BOREHOLE TYPE Hollow Stem Auger COMPILED BY P.T.
DATUM Geodetic DATE 91-07-05 CHECKED BY B.L.

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 7 KN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100					
407.3	Ground Surface												
0.0	Sand with Organics, trace Silt and Clay		1	SS	12								55 32 8 5
			2	SS	6								
			3	SS	23								48 41 9 1
			4	SS	29								
			5	SS	18								
	Heterogeneous mixture of Silt, Sand and Gravel, with Cobbles and Boulders (Glacial Till)												
	Compact to Dense		6	SS	47								49 42 8 1
			7	SS	24								
			8	SS	19								
	Interbedded Sand layers												
397.7			9	SS	40								9 83 3 5
9.6	End of Borehole												
	• Water level in open borehole												
	•• Water level of Creek at time of investigation												
394.2													
13.1	End of Cone Test							100/23cm					

Bennett, Betty (MTO)

From: Bennett, Betty (MTO)
Sent: November 9, 1999 01:16 PM
To: Garland, Nick (MTO)
Subject: Hwy 10 Culvert Site 24-31

Nick

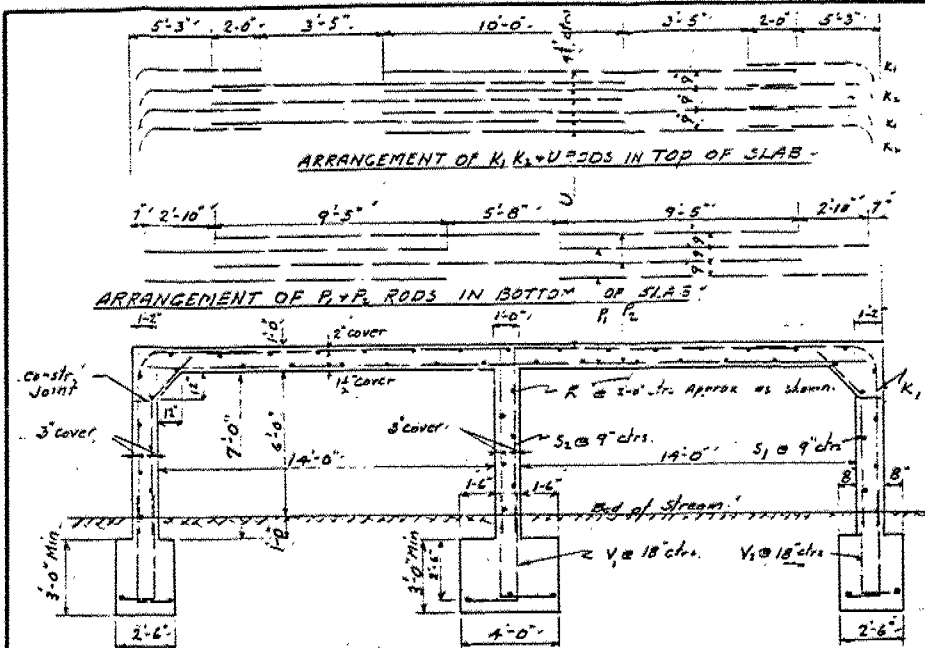
I had a look at the report for the culvert extension again. We could consider spread footings at this site. However, the values provided for bearing resistance in the report are unreasonably high. I discussed changing the values with Dave Dundas. More realistically, for a spread footing having width $B = 3$ m, the factored bearing resistance at ULS should be in the order of 700 kPa and the resistance at SLS, 325 kPa.

If these bearing values are high enough, then spread footings are an option here,

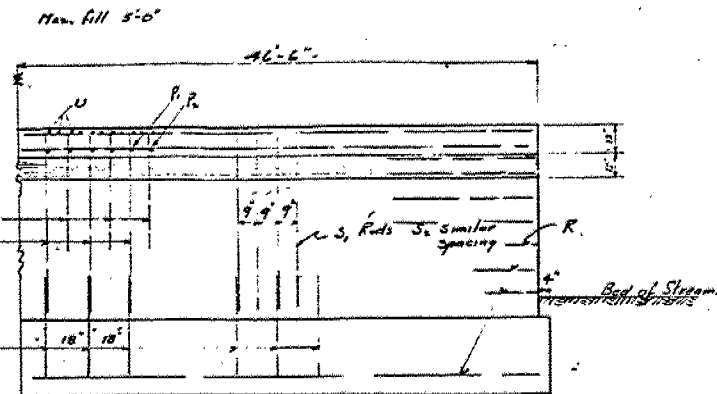
Should deep foundations be required, a foundation investigation is necessary to determine the pile lengths.

As far as the existing foundation report is concerned for shallow foundations, it doesn't meet our own terms of reference but could be considered adequate for this assignment if time does not permit additional work.

Betty



CROSS-SECTION

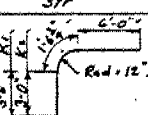


HALF LONGIT. SECTION

NOTE TO DISTRICT ENGINEER
Concrete work on this structure must not be commenced until monuments to fix control points have been erected & checked by the District Engineer.
GENERAL
Structure to be built in accordance with Form No. 9 (New) and the Special Provisions, extra copies of which may be obtained from the District Engineer.
All construction joints must be approved by the Bridge Engineer.

CONCRETE MIX

Maximum aggregate size - 1 1/2"
All concrete in this structure to be 3000 p.s.i. at 28 Days
Add 1/2 lb. Pozzolith "S" per bag of cement.

REINFORCING STEEL					
MARK	NO	SIZE	LENGTH	DETAIL	REMARKS
P1	124	3/8"	12'-3"	str	P, R in Bottom of slab alternate @ 9" ctrs. Staggered.
P2	62	3/8"	24'-6"	str	
K1	124	3/4"	13'-0 1/2"		in outside walls - corners Alternate @ 9" ctrs.
K2	124	5/8"	10'-6 1/2"		
U	248	3/8"	15'-5"		in top of slab @ 4 1/2" ctrs staggered.
S1	248	3/8"	8'-3"	str	in inside of outside walls @ 9" ctrs.
S2	248	3/8"	7'-6"	str	in centre well @ 9" ctrs.
V1	124	5/8"	6'-6"	4'-6"	Dowels in centre footing @ 18" ctrs.
V2	248	3/8"	5'-10"	1/2"	" - outside " " "
R	2801	5/8"	19'-9"	str	Longitudinal Tie @ 2'-0" ctrs + as shown. 56" lines 5" per line Lap 1-6
<p>Total Weight of steel = 26296 lbs</p>					

Rein A12325 V.P. 543-56

DEPARTMENT OF HIGHWAYS - ONTARIO
BRIDGE OFFICE - TORONTO

DOUBLE 14'x6'x93' OPEN R.F.

THE KING'S HIGHWAY No. 10 DIST. No. 5
CO. PEEL STA. 275+37
TWP. CALEDON LOT 14 CON. 12

GENERAL PLAN

APPROVED
SITE 24-31

BRIDGE ENGINEER DESIGN ENGINEER

DATE 20 April 1977

CONTRACT NUMBER 57-57
DRAWING NUMBER D-3922-1

DOCUMENT MICROFILMING IDENTIFICATION

G.I.-30 SEPT. 1976

GEOCRES No. 30 M13-124

DIST. 6 REGION

W.P. No. 130-79-01

CONT. No.

W. O. No.

STR. SITE No.

HWY. No. 10

LOCATION HWY 10, 5.1 KM SOUTH OF
HWY 24 TO CALEDON

=====

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:



Ministry
of
Transportation

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FOUNDATION DESIGN SECTION

**foundation
investigation and
design report**

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP 130-79-01

DIST 6

HWY 10

STR SITE

Proposed Road Widening for Highway 10

DISTRIBUTION

V.F. Boehnke (3)

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S.J. Dunham

E.A. Joseph

I. Harrod (Cover Only)

F. Bacchus (Cover Only)

File Copy

FOUNDATION INVESTIGATION REPORT
For
Proposed Road Widening for Highway 10
Highway 10, 5.1 km South of Highway 24 to Caledon
W.P. 130-79-01
District 6, Toronto

INTRODUCTION

Subsequent to requests submitted by the Central Region Geotechnical Section, an investigation was carried out by this office to determine foundation conditions at the location for a widening of Hwy. 10. The project would require 8-2 m high fills placed along side existing advanced structures. The proposed widening profile grades vary greatly in elevation from 382 m to 395.5 m uphill towards the north. Varying amounts of fill will be necessary to attain design profile grades. The natural ground surface varied from 379.6 m to 395.4 m as the project site is located on a rising hill northward.

The investigation procedure, include the field work, a detailed summary of the subsurface conditions and the requested design recommendations are included in this report.

SITE DESCRIPTION AND GEOLOGY

The above project is located between Sta.'s 16+000 to 16+250 6.75 km north of Peel Road 12 along Hwy. 10. The area is surrounded by farms and randomly placed private homes and consists of rolling grass-lands with groups of trees. To the south east there is a gulf-course and just south of the site Side Road 10 intersects Hwy. 10. Presently Hwy. 10 has 3 lanes and is constructed on approximately 12-15 m high embankments up the slope of the existing hill. The boreholes were placed two to the east and two to the west with one borehole located just off the shoulder (BH 4) and all others placed near the bottom of existing fill embankments.

Physiographically, the sites are located at the fringes of the physiographic regions known as the Oak Ridges Moraine and the Hillsburgh Sandhills. Much of the Oak Ridges Moraine for the most part are hills composed of sandy or gravelly materials, this is not always the case with some of the high ridges formed of

till which protudes above the sands. The rough topography, sandy materials, and flat bottomed swampy valley running through the moraine are the outstanding characteristics. Further west the sand gradually gives way to a till.

INVESTIGATION PROCEDURES

Soil data were obtained by in situ testing and examined in the laboratory. The fieldwork for the investigation was carried out between 91 05 30 to 91 06 03 and consisted of four boreholes located on the shoulder and near the embankments of Hwy. 10.

All boreholes were advanced 12.65 m below the existing ground surface.

Vanes were taken when plastic cohesive material was encountered. Cone Penetration Tests at the bottom of each borehole and one surface cone were performed. Location of the boreholes were based on the ETR sheets marked by the geotechnical section where the cross-sections for cut/fills are in excess of 4 m for which foundation investigations are required.

Track-mounted and truck-mounted CME55 equipment employing hollow stem and solid stem augering techniques was used to advance all boreholes in the overburden. In general disturbed subsoil samples were retrieved at 0.75 m intervals for the surficial 4.5 m and near the profile grade surface of the proposed widening, 1.5 m intervals thereafter. All samples were identified in the field and returned to the laboratory for review.

Groundwater levels were obtained by monitoring the levels in two piezometers installed and in open boreholes throughout the duration of the field investigation. All boreholes were backfilled at the completion of the fieldwork.

Survey information related to the location and elevation of boreholes was provided by the Central Region Surveys and Plans Office.

SUBSURFACE CONDITIONS

The stratigraphy encountered consists generally of 2 non-cohesive heterogeneous mixture of silt sand and gravel with pockets of organics, varying proportions of silt, sand and gravel with also some clayey silt at lower depths at two boreholes. This varying stratigraphy is primarily due to the locations of the boreholes being located at on top of existing fill or at a much lower elevation further away from the existing embankment. Therefore varying amounts or no fill was encountered. On the east side of Hwy. 10 (BH's 1 and 3) 0.3 m of a heterogeneous mixture of silt, sand and gravel, trace clay fill was encountered at one borehole (BH 1). Underlying this a sandy silt (till), some gravel with pockets of silty sand. Further north the other borehole (BH 3) contained 1.91 m of heterogeneous mixture of silty, sand and gravel, 3.45 m of silt, trace sand and then underlain by the heterogeneous mixture of silt, sand and gravel, interbedded with clayey silt. On the west side of Hwy. 10 (BH's 4 and 2) one Borehole (BH 4) was located on the top of the fill embankment while the other on the bottom (BH 2). Consequently the northern borehole (BH 4) contained 4.19 m of a heterogeneous mixture of silt, sand and gravel fill. Organics were encountered at 4.2 m. Underlying the above is the native heterogeneous mixture of silt, sand and gravel which was found to continue down to the terminated depth of the borehole. Boulders and gravels were encountered at 11.43 m. The southern borehole (BH 2) contained sandy silt (till) with pockets of clayey silt down to 11.43 m. Underlying this was a clayey silt, trace gravel down to the terminated depth of the borehole (12.65 m).

Depth to the groundwater table varied significantly between boreholes with depths ranging from 4.5 m to 10 m, the borehole on top of the embankment fill (BH 4) was dry. It should be noted that the groundwater table is always subject to seasonal fluctuations and is expected to rise during the spring and immediately following any periods of prolonged heavy rainfall.

Detailed descriptions of both the soil and groundwater conditions encountered at the boreholes are shown on Table 1 - Borehole Logs given at the back of this report. Borehole locations shown on sketch, Drawing No. 1307901-A.

DISCUSSION AND RECOMMENDATIONS

The existing Highway 10 running north/south consists of 2 lane to 4 lane segments and is constructed with a series of fills and cuts. It is proposed to widen the existing location which would involve the lateral extension of the existing embankments where the road is adjacent to a valley. This investigation includes the proposed embankments between Sta. 16+000 to 16+250. Embankment fills are expected to be from 4 m to an approximate maximum height of up to 12 m. Fills heights will vary greatly due to the sloping nature of the sites.

It appears from the boreholes drilled into the fill portion that except for traces of topsoil enclosures the existing embankment is constructed of fairly clean fill.

Design Considerations

For a foundation stability viewpoint, fills up to 8 m in height shall be constructed using a 2H:1V slope to flatter, provided any surficial organic matter encountered within the base limits of the fill is excavated and replaced by suitable embankfill fill material.

Fills of 8 m to 12 m in height shall be constructed using a 2H:1V slope, together with a 2 m wide midheight berm. The design of embankments as discussed above would have an adequate factor of safety from internal stability considerations. The fill material should consist of well compacted accepted material. Drainage and erosion protection of the slope should be carried out according to OPSS Standards.

It is anticipated that approximately 40 mm to 80 mm of the total settlement will be realized as a result of elastic settlements induced within the fill itself and the elastic recompression of the native subsoil. It is expected that the majority of these settlements will be realized during or immediately following construction.

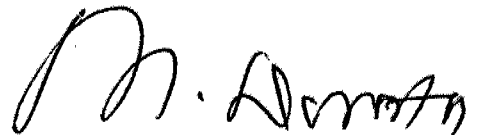
MISCELLANEOUS

The fieldwork for the investigation was carried out under the supervision of M. Michalek and J. Blair, Project Foundations Engineers and P. Thase, student engineer, utilizing equipment owned and operated by malones soil samples.

The project was carried out by M. Michalek under the general supervision of B. Iyer, Senior Foundation Engineer. The report was written by M. Michalek and reviewed and approved by B. Iyer.



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APPENDIX

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 (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	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

SS SPLIT SPOON	TP THINWALL PISTON
WS WASH SAMPLE	OS OSTERBERG SAMPLE
ST SLOTTED TUBE SAMPLE	RC ROCK CORE
BS BLOCK SAMPLE	PH TW ADVANCED HYDRAULICALLY
CS CHUNK SAMPLE	PM TW ADVANCED MANUALLY
TW THINWALL OPEN	FS 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_t	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^2	SEEPAGE FORCE
γ'	kn/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

Table I
Borehole Logs

Borehole No.	Depth		Elevation		Soil Description	Blows 'N'	Groundwater Table (m)
	From	To	From	To			
1 Sta. 16+015 32.0 m E O/S from CL	0	0.3	379.61	379.31	Heterogeneous mixture of Gravel, Sand and Silt, trace Clay (Fill)	16,19,39, 28,25,28,	3.9 (4.5)
	0.3	12.65	379.31	366.96	Sandy Silt (Till) some Gravel, trace Clay - Compact to Dense pockets of Silty Sand	26,9,28, -47,90,56	
2 Sta. 16+067 32.0 m W O/S from CL	0	1.14	377.83	376.69	Sandy Silt, some Gravel (Till)	6	12
	1.14	1.91	376.69	375.92	Pocket of Clayey Silt, trace Sand	3	
	1.91	11.43	375.92	366.4	Sandy Silt, interbedded Silt, trace Clay, trace Gravel	20,27,34, 30,29,61,25	
	11.43	12.65	366.4	365.18	Clayey Silt, trace Gravel, Stiff	14	
3 Sta. 16+127 32.0 m E O/S from CL	0	1.91	382.16	380.25	Heterogeneous mixture of Silt, Sand, and Gravel - Loose to Compact, Brown	16,5	
	1.91	5.36	380.25	376.8	Silt, trace Sand, trace Gravel, pockets of Clay - Compact to Very Dense	11,31,28,83	
	5.36	12.68	376.8	369.48	Heterogeneous mixture of Silt, Sand and Gravel interbedded Clayey Silt - Brown, Compact to Very Dense	58	
4 Sta. 16+237 31.0 m W O/S from CL	0	1.22	395.4		Organic topsoil (Fill) Clayey Silt, TR-SA some Grave, Very Stiff	19 19,9,7,13	
	1.22	4.19			Heterogeneous mixture of Silt, Sand, and Gravel (Fill) trace Clay - Loose		
	4.19	5.33			Heterogeneous mixture of Silt, Sand, and Gravel Organics, Dark Brown - Compact	10	
	5.33	11.43			Heterogeneous mixture of Silt, Sand and Gravel, pockets of Silt and Sand - Compact to Very Dense	16,58,89,20	
	11.43	12.65			Boulders and Gravel, trace Silt	77	

W.P. 130-79-01

METRIC

NOTE - DIMENSIONS ARE IN
METRES AND/OR
MILLIMETRES UNLESS
OTHERWISE SHOWN.

