



**FOUNDATION TECHNICAL MEMORANDUM**

**For**

**BRANT ROAD 16 (BISHOPSGATE ROAD) UNDERPASS  
HIGHWAY 403**

**MTO WEST REGION 59 STRUCTURE REHABILITATIONS  
SITE 1-155, CONTRACT 8**

**GWP 3094-12-00**

**TOWNSHIP OF BRANTFORD**

**BRANT COUNTY, ONTARIO**

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Appendix A – Previous Foundation Investigation Reports (GEOCRES 40P01-53)

- Reference 1. Foundation Investigation Report for County Road 16 Revision Underpass, 3.9 km West of Hwy. #24A, W.P. 161-60-01, Site No. 1-155, Hwy. #403, District #4 (Hamilton), Contract No. 81-43. dated February 3, 1982 GEOCRES No. 40P1-53.
- Reference 2. Foundation Investigation Report for the Overhead Structure of Proposed C.A.H. #403 Line “E”, and Revised County Rd. # 16, 6.2 Mi. West of Brantford West Limits, District #4 (Hamilton), W.O. 71-11108, W.P. 161-60-00, dated March 23, 1972, GEOCRES No. 40P1-53.



- Reference 3. General Arrangement Drawing, County Rd, # 16 U'Pass, 3.9 Km west of Hwy. 24A, DWG 1, Sheet 155, Site No. 1-155, District No. 4, W.P. No. 161-60-01, Contract No. 81-43, dated September, 1980.
- Reference 4. Footing Layout & Reinforcing Drawing, County Rd. 16 U'Pass, 3.9 Km west of Hwy. 24A, DWG 3, Site No. 1-155, CONT. No. 81-43, W.P. 161-60-01, Sheet 157, dated September, 1980.

#### Appendix B – Site Photographs

**FOUNDATION TECHNICAL MEMORANDUM**

**For**

Brant Road 16 Underpass, Highway 403  
MTO West Region 59 Structure Rehabilitations  
Site 1-155, Contract 8, GWP 3094-12-00  
Township of Brantford  
Brant County, Ontario

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**1. INTRODUCTION**

The Foundation Engineering Services for the present project involve the detail foundation investigation and design for the rehabilitation of 59 structures in MTO West Region along Highways 4, 6, 401, 402 and 403. Ten (10) Group Work Projects (GWP's) are contemplated to be completed between 2014 and 2020.

This technical memorandum summarizes the factual results of geotechnical data based on the review and compilation of existing subsurface information from relevant reports in the MTO GEOCRES Library for the Brant Road 16 Underpass Highway 403. The Foundation Engineering recommendations from the initial foundation reports are summarized with reference to the "Canadian Highway Bridge Design Code" (CHBDC) and follow in general the "Guidelines for Professional Engineers providing Geotechnical Engineering Services".

From the Minutes of Meeting Report, dated February 9, 2016, it is understood that a minor rehabilitation consisting of expansion joint replacement and barrier wall rehabilitation will be undertaken for this structure because the County of Brant has undertaken an environmental assessment (EA) for a proposed interchange at this location.

The purpose of the technical memorandum is to summarize the subsurface and groundwater conditions and foundation recommendations based on available reports at the structure location for the design project team's reference.

The elevations in this report are expressed in meters, unless otherwise noted.





## **2. PROJECT SITE BACKGROUND AND GEOLOGY**

The Brant Road 16 (currently Bishopsgate Road) Underpass Highway 403 is located about 5.5 km southwest of Town of Paris in Brant County, Ontario. A key plan is shown in Figure 1.

The existing underpass is a two span post tensioned concrete voided slab structure that carries two through lanes over Highway 403. The immediate vicinity is relatively flat. Agricultural lands at the north and south sides were observed with some wooded areas in the vicinity of the structure.

Physiographically, the site of the underpass is located in the region referred to as Norfolk Sand Plain. The sands and silts of this region were deposited as a delta in glacial lakes Whittlesey and Warren. The deposits range in thickness from 1.0 to 20.0 m with an average thickness of 5.0 to 10.0 m. Most of the drainage is by relatively short rivers and streams that cut deeply into the sand plain. Drainage is good near the main streams and their tributaries. However, in some intermorainal and interfluvial sections, the drainage is poor. The bedrock underlying the area consists of alternating layers of gray shale and dolostone of Salina Formation of Upper Silurian. The bedrock surface at the site location is between elevation 213.0 and 221.0 (Map 2035, Bedrock Topography of the Brantford Area, Southern Ontario, Ontario Department of Mines).

## **3. SOURCE OF INFORMATION**

The following reports and drawings, appended in Appendix A, were available for review and information for the underpass structure, subsoil information and original foundation recommendations.

1. Foundation Investigation Report for County Road 16 Revision Underpass, 3.9 km West of Hwy. #24A, W.P. 161-60-01, Site No. 1-155, Hwy. #403, District #4 (Hamilton), Contract No. 81-43. Foundation Office, Department of Transportation and Communications, dated February 3, 1982 (received by Pavement and Foundation Design Section), GEOCREC No. 40P1-53. (Reference 1)



2. Foundation Investigation Report for the Overhead Structure of Proposed C.A.H. #403 Line "E", and Revised County Rd. # 16, 6.2 Mi. West of Brantford West Limits, District #4 (Hamilton), W.O. 71-11108, W.P. 161-60-00. Foundation Office, Department of Transportation and Communications, dated March 23, 1972, GEOCREs No. 40P1-53. (Reference 2)
3. General Arrangement Drawing, County Rd, # 16 U'Pass, 3.9 Km west of Hwy. 24A, DWG 1, Sheet 155, Site No. 1-155, District No. 4, W.P. No. 161-60-01, Contract No. 81-43, dated September, 1980. (Reference 3)
4. Footing Layout & Reinforcing Drawing, County Rd. 16 U'Pass, 3.9 Km west of Hwy. 24A, DWG 3, Site No. 1-155, CONT. No. 81-43, W.P. 161-60-01, Sheet 157, dated September, 1980. (Reference 4)

#### **4. SITE RECONNAISSANCE**

As part of the current foundation engineering assessment study, a site reconnaissance of the Brant Road 16 Underpass Highway 403 was carried out on August 28, 2015 by PML representative.

The site photographs present the current conditions of the Brant Road 16 Underpass including visible portions of the abutments and pier, and abutment slope assessment based on visible areas, apparent areas of soil erosion and abutment slope cover.

The site inspection revealed that the vicinity of the underpass structure abutment locations was covered by vegetation. Both abutment front slopes were covered by concrete panels (Photographs 1 and 2). Minor cracks were observed in the concrete panel on the north side (Photograph 3). At the time of inspection, some of the weep holes in the abutment walls observed assessed to be clogged inside (Photographs 1 and 2). Both east and west slopes adjacent to the abutments were observed to be vegetated and no evidence of slope erosion was noted (Photographs 5 to 8). Minor cracks were observed on the east and west wingwalls of the north and south abutments (Photographs 5 to 8). The centreline pier at the time of site reconnaissance was observed with minor surficial cracks with no spalling of concrete or exposure of rebar.



## **5. PREVIOUS FOUNDATION INVESTIGATION AND SUBSURFACE CONDITIONS**

A revised foundation investigation report (Reference 1), included only the factual subsurface and groundwater conditions, was prepared by Department of Transportation and Communications, dated February 3, 1982 (received by Pavement and Foundation Design Section). The general subsurface conditions presented in this section are based on the foundation investigation report referred in Reference 1.

The field investigation was carried out during the period of January 14 to 25, 1972 for the project that included a total of eight boreholes (numbered 1 to 8) with two boreholes (nos. 5 and 8) accompanied by dynamic cone penetration test (DCPT) and eight individual DCPTs (nos. 9 to 16).

The Foundation Investigation Report (Reference 1) includes the Borehole Location and Soil Strata Drawing (Drawing 2, dated January 17, 1980) and Record of Borehole sheets. The general layout of the structure is shown in Reference 1.

The boreholes 1 to 8 were advanced to depths of 8.8 to 23.6 m below ground surface, elevation 231.5 to 246.7. The eight individual DCPTs in boreholes 9 to 16 were advanced to termination depths of 2.4 to 14.0 m below ground surface, elevation 241.0 to 253.2.

The boreholes were drilled by a continuous flight auger machine equipped with 83 mm I.D. hollow stem augers. The dimensions of the spoon sampler and the energy used in driving it conform to the requirements of the Standard Penetration Test. Soil samples were obtained by means of split spoons and 50 mm (2.0 in.) diameter Shelby tubes. In-situ field vane tests were carried out in the cohesive layer to determine undrained shear parameters.

The samples obtained were visually examined in the field after recovery and again in the laboratory upon arrival. Laboratory tests, including moisture content determinations, Atterberg limits and grain size analyses, were conducted on selected samples to determine the physical properties of the soil specimens. In addition, unconfined compression test was carried out on selected samples in the laboratory to determine undrained shear parameters of the cohesive layer. All field and laboratory tests results were plotted on the Record of Borehole Sheets.



## **5.1 General**

Generally, in the boreholes, surficial 4.9 to 8.7 m thick compact to very dense gravelly sand to sandy gravel overlaid compact to very dense sandy silt to silty sand which in turn overlaid stiff to hard clayey silt were encountered.

### **5.1.1 Gravelly Sand to Sandy Gravel**

The surficial layer in all eight boreholes (numbered 1 to 8) was identified as a granular deposit of gravelly sand to sandy gravel with traces of silt. The layer thickness varied between 4.9 and 8.7 m below ground surface, elevation 246.4 and 250.1. The uppermost layer (0.9 to 1.2 m) below the ground surface of the material was usually compact with N values ranging between 10 and 16, except for one penetration N value of 8 in borehole 6. N values recorded ranged between 10 and 103 blows for 0.23 to 0.3 m penetration on east side (boreholes 1 to 4) and between 8 and 85 on west side (boreholes 5 to 8) respectively. The relative density increased rapidly below 1.2 m with N values being near and above 100 at the east side. On the west side, the N value averaged around 45 to 50. The compactness of the gravelly sand to sandy gravel was compact to very dense with a localized upper loose zone in borehole 6.

Grain size analyses carried out on representative samples obtained 4 to 61% gravel, 32 to 92% sand, and 2 to 22% silt sized particles. The moisture content determinations of the samples decreased with depth from around 20% near the surface to moisture content between 8 and 9% further down.

### **5.1.2 Silty Sands to Sandy Silt**

A 1.6 to 4.7m thick discontinuous silty sand to sandy silt layer was encountered below the gravelly sand to sandy gravel layer in all boreholes, except boreholes 5 and 6, at 4.9 to 8.7 m, elevation 246.4 to 250.1. The discontinuous layer extended to 7.0 to 12.5 m below ground surface, elevation 242.6 to 248.0. Boreholes 1 and 2 were terminated in this at 8.8 and 10.4 m, elevation 246.7 and 245.0, respectively. N values recorded ranged between 17 and 74 on east side (boreholes 1 to 4) and between 16 and 29 on west side (boreholes 7 and 8) respectively. The



layer encountered was compact to very dense silty sand to sandy silt soils. It was indicated that the low N values might have been caused by the uplift pressure of the unbalanced groundwater head due to the uniform grain-size distribution of this cohesionless material. The moisture content of the silty sand to sandy silt deposits ranged between 11 and 18%.

A lower deposit of sandy silt with some clay was encountered in borehole 8 below a clayey silt deposit at 15.8 m, elevation 239.1, which extended to the termination depth of the borehole at 22.6 m, elevation 232.3. N values obtained ranged between 52 and 78 with one N value of 100 blows for 0.15 m penetration, indicating very dense layer.

Grain size analyses were carried out on selected silty sand representative samples. The samples contained 0 to 2% gravel, 56 to 81% sand, 17 to 43% silt and clay sized particles.

Grain size analyses were also carried out on selected sandy silt representative samples. The selected samples consisted 0 to 25% gravel, 13 to 40% sand, 49 to 80% silt and 7 to 15% clay sized particles.

One sample (sample number 9) obtained from borehole 2 indicated that the sandy silt deposit transitioned to clayey silt, which was revealed by a grain size analysis and accompanying Atterberg limits. The grain size distribution results obtained 0% gravel, 3% sand, 74% silt and 23% clay sized particles. The Atterberg liquid and plastic limits of the sample were 19 and 14 with a plasticity index of 5.

#### 5.1.3 Clayey silt

A 0.6 to 12.3 m thick discontinuous cohesive clayey silt layer was encountered in boreholes 3 to 8 at 5.7 to 12.5 m, elevation 242.6 to 249.3, which extended to the termination depths of the boreholes, except borehole 8, at 9.1 to 23.6 m below ground surface, elevation 231.5 to 246.0. Borehole 8 fully penetrated the 8.0 m thick clayey silt layer at 15.8 m, elevation 239.1. N values recorded ranged between 19 and 94 with 100 blows for 0.15 to 0.20 m penetration in borehole 4, indicating very stiff to hard consistency. Below elevation 239.3, the consistency of the clayey silt becomes hard.



Grain size distribution results obtained on selected samples included 0 to 8% gravel, 2 to 23% sand, 51 to 68% silt and 14 to 37% clay sized particles. The Atterberg liquid limits of the clayey silt samples ranged between 18 and 31 and plastic limits ranged between 12 and 18. The plasticity index values ranged between 4 and 13. The unit weights determined on selected cohesive soil samples ranged between 20.6 and 21.2 kN/m<sup>3</sup>. The average laboratory and field undrained shear strength indicated was 96.0 kPa. The natural moisture contents of the samples ranged between 13 and 21%.

## **5.2 Groundwater**

The stabilized groundwater levels in the boreholes were established at elevation 254.2 to 254.5, some 0.6 to 0.9 m below ground surface at the time of the investigation. Due to the high water levels, in some locations, unstable conditions were observed in the borings within the uniform sandy silt to silty sand layer. The relatively low penetration resistances, N values, were considered to be due to the uplift pressure of this unbalanced hydrostatic head.

## **6. FOUNDATION**

### **6.1 Previous Foundation Recommendations**

The previous foundation recommendations presented in the following sections are based on the original report (Reference 2). It was recommended that the proposed structure be constructed as twin overpass structure for the future Highway 403, Line 'E' at the crossing of Brant Road 16 Revision. The grade of Highway 403 at the crossing was designed to be at elevation 262.1 (860 ft.) with approach fill of 6.7 to 7.6 m (22.0 to 25.0 ft.). It was assumed that the structure would be built with spill through type abutments.

#### **6.1.1 Abutments**

The original foundation investigation report (Reference 2) recommended that the most economical alternative for abutments was to be supported on piles. It was indicated that the pile caps could be placed within the approach fill embankment. Based on the General Arrangement Drawing



(Reference 3), the top of the 800 mm thick pile caps was at elevation 259.0 and 258.4 at the north and south abutments, respectively. The report recommended utilizing 323.85 mm (12.75 in.) outer diameter (O.D) steel tube piles with 6.35 mm (0.25 in.) thick wall thickness driven to 620.0 kN (70 ton) per pile capacity as determined by the Hiley formula.

At the east abutment location it was estimated that the 620 kN (70 ton) per pile design load could be reached by driving the piles through the fill and about 3.0 m (10.0 ft.) into the native soil at approximate tip elevation 252.1 to 252.4 (827.0 to 828.0 ft.). At the west abutment location, the soil condition was found less favourable. The report suggested longer piles be driven to 233.1 to 236.2 (765.0 to 775.0 ft.) in order to achieve 620 kN (70 ton) per ton design load. The report emphasized that the working load on the piles would need to be checked during pile driving by the use of Hiley formula. It was recommended that the approach fills at the abutment locations should be devoid of bouldery material.

Based on the General Arrangement drawing (Reference 3), the abutments were to be founded on 323.85 mm (12.75 in.) O.D. steel tube piles (weight 49.73 kg/m) driven in accordance with Standard SS 103-11. The design load of the piles was shown to be 400 kN (45 tons) per pile. It was noted in the drawing that the piles were not to be driven below elevation 251.0.

The following table summarizes the pile data based on the Footing Layout & Reinforcing Drawing (Reference 4).



SUMMARY OF PILE DATA					
LOCATION	ROW	NUMBER REQUIRED	LENGTH, mm	BATTER	PILE CUT-OFF ELEVATION, m
North Abutment	Front	12	8000	1:3	258.550
	Middle	8	7750	1:8	
	Back	2	7750	Vertical	
South Abutment	Front	12	7500	1:3	257.95
	Middle	8	7000	1:8	
	Back	2	7000	Vertical	

#### 6.1.2 Piers

In the report (Reference 2), the most economical type of foundation recommended for the east and west piers was spread footing to be founded at or below the elevation 253.6 (832.0 ft.) and proportioned employing a safe design load of 240 kPa (2.5 tsf).

The groundwater level at the site was encountered at elevation 254.2 to 254.5 (834.0 to 835.0 ft.), some 0.6 to 0.9 m (2.0 to 3.0 ft.) above the recommended footing bases. Due to the groundwater level and presence of granular type of the subsoil, it was anticipated that quick sand condition may occur at the bottom of the excavations due to unbalanced hydrostatic head. In order to mitigate the condition, it was recommended that a dewatering scheme be executed with necessary precautions.

Based on the General Arrangement drawing (Reference 3), the pier was supported on 1.65 m thick 6.5 by 6.9 m spread footing founded at elevation 253.1 (830.4 ft.).

#### 6.1.3 Approach Fills

In the report (Reference 2), 6.7 to 7.6 m (22.0 to 25.0 ft.) high approach fills were proposed. The report (Reference 2) indicated that no stability problems were expected for the high approach fills provided that the approaches were constructed with 2 horizontal to 1 vertical slope.





Based on the General Arrangement drawing (Reference 3) about 9.0 to 10.0 m of fill was anticipated in order to achieve the approach grade of Brant Road No. 16.

## 6.2 Assessment of Foundation Parameters

Based on the previous investigation and subsurface conditions encountered, the following table summarizes the foundation design parameters that were recommended in the previous report, contract drawings and the updated geotechnical reaction at SLS and factored geotechnical resistance at ULS are provided.

FOUNDATION DESIGN PARAMETERS

FOUNDATION FOUNDATION TYPE	PROBABLE PILE TIP/ SPREAD FOOTING ELEVATION <sup>1</sup>	PREVIOUS WORKING STRESS VALUES <sup>2</sup>	PREVIOUS EQUIVALENT LIMIT STATE DESIGN VALUES		LIMIT STATE DESIGN VALUES UPDATED TO CURRENT INDUSTRY PRACTICE <sup>3</sup>	
		SAFE BEARING RESISTANCE/LOAD	SLS BEARING REACTION/LOAD	ULS FACTORED GEOTECHNICAL RESISTANCE/LOAD	SLS BEARING REACTION/LOAD	ULS FACTORED GEOTECHNICAL RESISTANCE/LOAD
North abutment (Tube Piles)	251.0  (Piles not to be driven below this elevation)	400 kN (45 tons)	400 (kN)	480 (kN)	435 (kN)	520 (kN)
South abutment (Tube Piles)						
Piers (Spread Footings)	253.1	2.5 (tsf)	240 (kPa)	360 (kPa)	265 (kPa)	400 (kPa)

- Notes:**
1. Founding elevation and loads are from References 3 and 4.
  2. Working stress design values based on References 2 and 3. The Serviceability Limit State design values are based on the working stress. No field verifications were made.
  3. Resistance Factor = 0.4 for deep foundations (CFEM 4<sup>th</sup> edition)  
Assumed Factor of Safety is 3 (CFEM 4<sup>th</sup> edition).

The Peak Ground Acceleration (PGA) for the site is 0.084 (National Building Code of Canada, 2015). The soil classification for seismic design should be in accordance with Clause 4.4.3.2 of the CHBDC (2014).

The bearing resistance for inclined loads should be reduced in accordance with the requirements of clause 6.10.4 of the CHBDC 2014 Edition.



The foundation frost penetration depth at the site is 1.2 m according to OPSD 3090.101.

## **7. DISCUSSION**

It is understood that a minor rehabilitation consisting of expansion joint replacement and barrier wall rehabilitation will be undertaken for this structure because the County of Brant has undertaken an environmental assessment (EA) for a proposed interchange at this location. From a geotechnical point of view, at the present time, foundation work for underpass structure is not expected.

However, if any major rehabilitation is undertaken for the proposed interchange at this location, it is recommended that the foundation capacity at the abutment locations should be verified prior to any major construction work. Further, the Structural Engineer should verify the pile type and configuration used for the underpass structure.

A temporary support system may be required for the rehabilitation of the underpass structure and the construction for temporary support system should conform to OPSS 404 and 539. The contractor is responsible for the selection, detailed design and performance of the roadway protection scheme. The contractor should monitor the movement of the roadway protection system.

The slopes adjacent to both abutments are visually stable without signs of erosion. However, the embankments which are greater than 8.0 m in height were constructed with a 2H:1V slope but not benched as per current practice (OPSD 202.010).

Furthermore, it is suggested that the weep holes in the abutment walls should be maintained and cleaned at a regular basis to prevent any clogging of the holes. Regular maintenance of the weep holes will keep the water flowing from behind the abutment walls and will mitigate hydrostatic pressure to build-up behind the abutment walls.



## 8. CLOSURE

This Technical Memorandum was prepared by Mr. N. Rahman, P.Eng, Project Engineer and was reviewed by Mr. B. R. Gray, M.Eng, P.Eng., Principal Consultant. Mr. R. Ng, MBA, PhD, P.Eng., MTO Designated Principal Contact conducted an independent review of the report.

We trust this memo is sufficient for your immediate needs. Please, do not hesitate to contact us if you have any inquiries and/or comments.

Yours very truly,

Peto MacCallum Ltd.



Nazibur Rahman, P.Eng  
Project Engineer



Brian R. Gray, M.Eng, P.Eng  
Principal Consultant



Robert Ng, MBA, PhD, P.Eng.  
MTO Designated Principal Contact

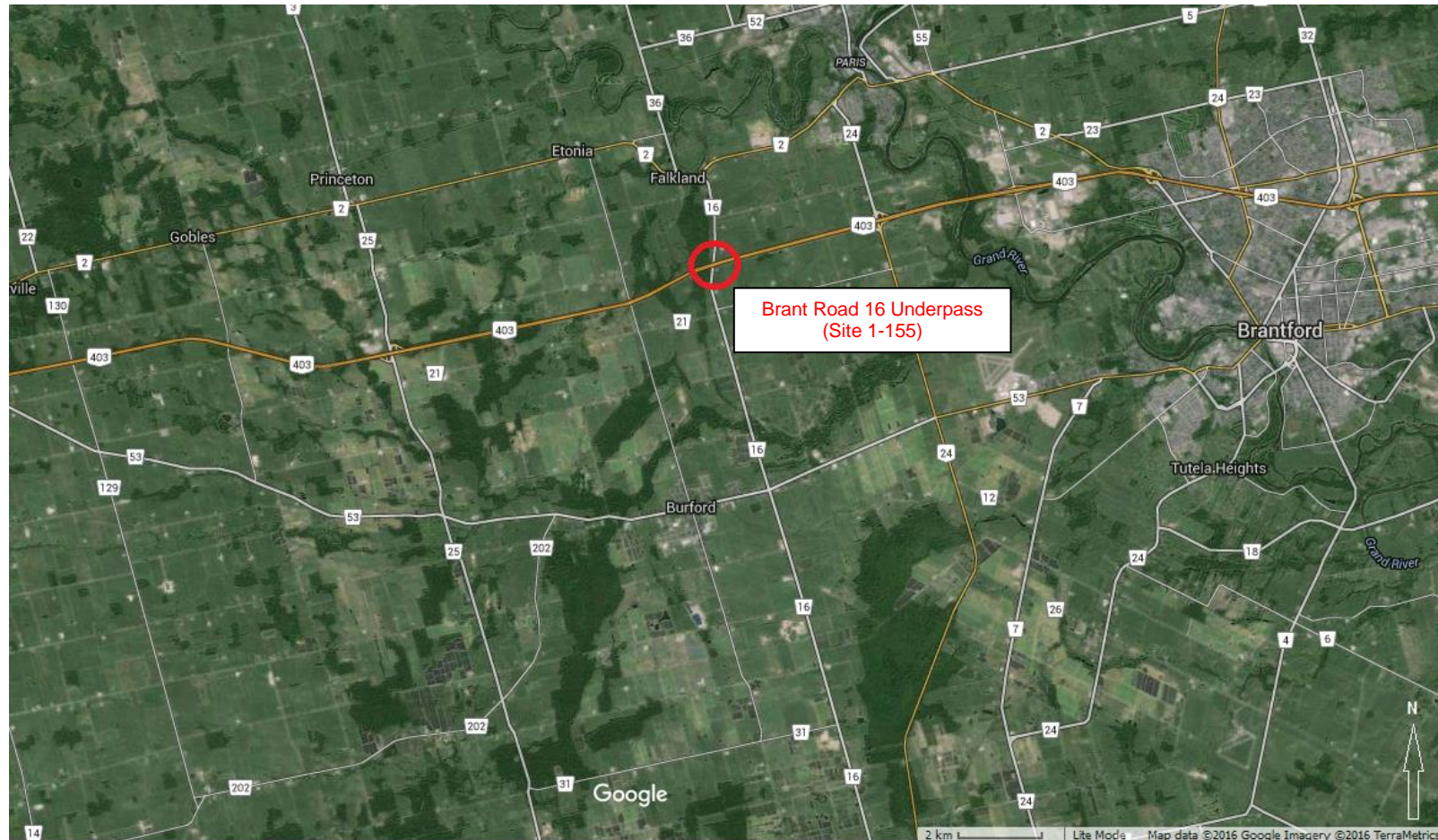


TABLE 1

LIST OF STANDARD SPECIFICATIONS REFERENCED IN REPORT

DOCUMENT	TITLE
OPSS 404	Construction Specification for Support Systems
OPSS 539	Construction Specification for Temporary Protection Systems
OPSS.PROV 1004	Material Specification for Aggregates - Miscellaneous
OPSD 202.010	Slope Flattening Using Surplus Excavated Material On Earth or Rock Embankment
OPSD 3090.101	Foundation Frost Depth for Southern Ontario

**Figure 1 – Key Plan**





## **APPENDIX A**

### Previous Foundation Investigation Reports (GEOCRES 40P1-53)

- Reference 1. Foundation Investigation Report for County Road 16 Revision Underpass, 3.9 km West of Hwy. #24A, W.P. 161-60-01, Site No. 1-155, Hwy. #403, District #4 (Hamilton), Contract No. 81-43, dated February 3, 1982 GEOCRES No. 40P1-53.
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DOCUMENT MICROFILMING IDENTIFICATION

Reference 1

GEOCRES No. 40P1-53

DIST. 4 REGION                     

W.P. No. 161-60-00

CONT. No. 81-43

W. O. No.                     

STR. SITE No. 1-155

HWY. No. 403

LOCATION County Rd. 16 Overpass

No of PAGES -



OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.                     

REMARKS:                     

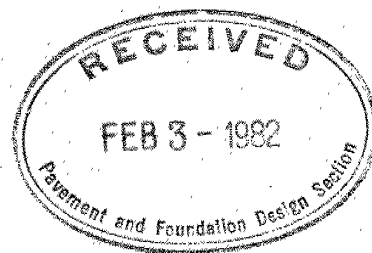
                    

G.I.-30 SEPT. 1976

# FOUNDATION INVESTIGATION REPORT

CONTRACT NO 81-43



Ministry of  
Transportation and  
Communications



1

INDEX

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**Note:** For purposes of the Contract these reports supercede all other foundation reports prepared by or for the Ministry in connection with the above mentioned projects.

# 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
$C_\alpha$	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
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	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
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### PHYSICAL PROPERTIES OF SOIL

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

EXTENDED CASAGRANDE SOIL CLASSIFICATION SYSTEM																	
FIELD IDENTIFICATION PROCEDURES (EXCLUDING PARTICLES LARGER THAN 75 mm AND BASING FRACTIONS ON ESTIMATED MASS)					GRP SYMB	TYPICAL NAMES	INFORMATION REQUIRED FOR DESCRIBING SOILS	LABORATORY CLASSIFICATION CRITERIA									
COARSE GRAINED SOILS MORE THAN HALF OF MATERIAL IS LARGER THAN 75 μm (75 μm IS ABOUT THE SMALLEST PARTICLE VISIBLE TO THE NAKED EYE)	GRAVELS	CLEAN GRAVELS (LITTLE OR NO FINES)	WIDE RANGE IN GRAIN SIZE & SUBSTANTIAL AMOUNTS OF ALL INTERMEDIATE PARTICLE SIZE		GM	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES; LITTLE OR NO FINES	GIVE TYPE; NAME, IF NECESSARY, INDICATE APPROX. % OF SAND & GRAVEL; MAX. SIZE; ANGULARITY, SURFACE CONDITION, & HARDNESS OF THE COARSE GRAINS; LOCAL OR GEOLOGIC NAME & OTHER PERTINENT DESCRIPTIVE INFORMATION; & A SYMBOL IN PARENTHESES.  FOR UNDISTURBED SOILS ADD INFORMATION ON STRATIFICATION, DEGREE OF COMPACTNESS, CEMENTATION, MOISTURE CONDITIONS & DRAINAGE CHARACTERISTICS.	DETERMINE PERCENTAGES OF GRAVEL & SAND FROM GRAIN SIZE CURVE. DEPENDENT ON PERCENTAGE OF FINES (FRACTION SMALLER THAN 75 μm) COARSE GRAINED SOILS ARE CLASSIFIED AS FOLLOWS:  LESS THAN 5% GM, GP, SW, SP MORE THAN 12% GM, GC, SM, SC 5% TO 12% BORDERLINE CASES REQ. USE OF DUAL SYMBOLS		$C_u = \frac{D_{60}}{D_{10}}$ GREATER THAN 4 $C_c = \frac{(D_{30})^2}{D_{10} \cdot D_{60}}$ BETWEEN ONE AND 3							
			PREDOMINANTLY ONE SIZE OF A RANGE OF SIZES WITH SOME INTERMEDIATE SIZES MISSING		GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES; LITTLE OR NO FINES				NOT MEETING ALL GRADATION REQUIREMENTS FOR GM							
		GRAVEL WITH FINES (APPRECIABLE AMOUNT OF FINES)	NON-PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE ML BELOW)		GM	SILTY GRAVELS, POORLY GRADED GRAVEL-SAND-SILT MIXTURES				ATTERBERG LIMITS BELOW A-LINE, OR $I_p$ LESS THAN 4							
			PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE CL BELOW)		GC	CLAYEY GRAVELS, POORLY GRADED GRAVEL-SAND-CLAY MIXTURES				ATTERBERG LIMITS ABOVE A-LINE WITH $I_p$ GREATER THAN 7							
	SANDS	CLEAN SANDS (LITTLE OR NO FINES)	WIDE RANGE IN GRAIN SIZES & SUBSTANTIAL AMOUNTS OF ALL INTERMEDIATE PARTICLE SIZES		SM	WELL GRADED SANDS, GRAVELLY SANDS; LITTLE OR NO FINES		GIVE TYPE; NAME, IF NECESSARY, INDICATE DEGREE & CHARACTER OF PLASTICITY, AMOUNT & MAXIMUM SIZE OF COARSE GRAINS, COLOUR IN WET CONDITION, ODOUR, IF ANY, LOCAL OR GEOLOGIC NAME & OTHER PERTINENT DESCRIPTIVE INFORMATION & A SYMBOL IN PARENTHESES.  FOR UNDISTURBED SOILS AND INFORMATION ON STRUCTURE, STRATIFICATION, CONSISTENCY IN UNDISTURBED & REMOULDED STATES, MOISTURE & DRAINAGE CONDITIONS.	$C_u = \frac{D_{60}}{D_{10}}$ GREATER THAN 4 $C_c = \frac{(D_{30})^2}{D_{10} \cdot D_{60}}$ BETWEEN ONE AND 3		NOT MEETING ALL GRADATION REQUIREMENTS FOR SW						
			PREDOMINANTLY ONE SIZE OR A RANGE OF SIZES WITH SOME INTERMEDIATE SIZES MISSING		SP	POORLY GRADED SANDS, GRAVELLY SANDS; LITTLE OR NO FINES					ATTERBERG LIMITS BELOW A-LINE OR $I_p$ LESS THAN 4						
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	NON-PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE ML BELOW)		SM	SILTY SANDS, POORLY GRADED SAND-SILT MIXTURES					ATTERBERG LIMITS ABOVE A-LINE WITH $I_p$ GREATER THAN 7						
			PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE CL BELOW)		SC	CLAYEY SANDS, POORLY GRADED SAND-CLAY MIXTURES					ATTERBERG LIMITS ABOVE A-LINE WITH $I_p$ GREATER THAN 7						
	IDENTIFICATION PROCEDURES ON FRACTION SMALLER THAN 425 μm																
	FINE GRAINED SOILS MORE THAN HALF OF MATERIAL IS SMALLER THAN 75 μm (75 μm IS ABOUT THE SMALLEST PARTICLE VISIBLE TO THE NAKED EYE)	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50%	DRY STRENGTH (CRUSHING CHARACTERISTICS)	PLATENCY (REACTION TO SHAKING)	TOUGHNESS (CONSISTENCY NEAR PLASTIC LIMIT)	ML		INORGANIC SILTS & SANDY SILTS OF SLIGHT PLASTICITY, ROCK FLOUR	GIVE TYPE; NAME, IF NECESSARY, INDICATE DEGREE & CHARACTER OF PLASTICITY, AMOUNT & MAXIMUM SIZE OF COARSE GRAINS, COLOUR IN WET CONDITION, ODOUR, IF ANY, LOCAL OR GEOLOGIC NAME & OTHER PERTINENT DESCRIPTIVE INFORMATION & A SYMBOL IN PARENTHESES.  FOR UNDISTURBED SOILS AND INFORMATION ON STRUCTURE, STRATIFICATION, CONSISTENCY IN UNDISTURBED & REMOULDED STATES, MOISTURE & DRAINAGE CONDITIONS.							
CL							CLAYEY SILTS (INORGANIC), GRAVELLY CLAYS, SANDY CLAYS, LEAN CLAYS										
OL							ORGANIC SILT OF LOW PLASTICITY, ORGANIC SANDY SILTS										
LIQUID LIMIT BETWEEN 50% AND 90%				NONE TO SLIGHT	SLOW TO QUICK	SLIGHT	MI	INORGANIC COMPRESSIBLE FINE SANDY SILT WITH CLAY OF MEDIUM PLASTICITY, CLAYEY SILTS									
				HIGH	NONE	MEDIUM TO HIGH	CI	SILTY CLAYS (INORGANIC) OF MEDIUM PLASTICITY									
				SLIGHT TO MEDIUM	VERY SLOW	SLIGHT	OI	ORGANIC SILTY CLAYS OF MEDIUM PLASTICITY									
LIQUID LIMIT GREATER THAN 90%			SLIGHT TO MEDIUM	SLOW TO NONE	MEDIUM	MH	INORGANIC SILTS, HIGHLY COMPRESSIBLE MICACEOUS OR DIATOMACEOUS FINE SANDY SILTS, ELASTIC SILTS										
			HIGH TO VERY HIGH	NONE	HIGH	CH	CLAYS (INORGANIC) OF HIGH PLASTICITY, FAT CLAYS										
			MEDIUM TO HIGH	NONE TO VERY SLOW	SLIGHT TO MEDIUM	OH	ORGANIC CLAYS OF HIGH PLASTICITY										
HIGHLY ORGANIC SOILS					PL	PEAT & OTHER HIGHLY ORGANIC SOILS											

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

## FOUNDATION INVESTIGATION REPORT

For

County Road 16 Revision Underpass  
3.9 Km West of Hwy. #24A  
W.P. 161-60-01; Stie No. 1-155  
Hwy. #403, District #4 (HAMILTON)

INTRODUCTION

A foundation investigation was carried out during the period of 72-01-14 and 72-01-25 for the above project. The field work consisted of eight sampled boreholes with two accompanied by dynamic cone penetration tests and eight individual cone tests. The boreholes were advanced by a continuous flight auger machine equipped with 83mm I.D. hollow stem augers.

SITE DESCRIPTION AND GEOLOGY (At the time of the Field Investigation)

The terrain at the bridge site is relatively flat farmland, used mainly for crops. There are some small woods in the vicinity and some swampy areas farther to the south.

Geologically the site is part of the physiographic region known as the Norfolk Sand Plain. The sands and silts of this region were deposited as a delta in glacial lakes Whittlesey and Warren. The sand beds are usually followed within 9m of the surface by silts and clays. The sands in the inter-morainal and other interfluvial sections of the plain are rather wet, for the lack of proper drainage.

SUBSURFACE CONDITIONS (At the time of the Field Investigation)General:

The subsoil at the site was found to consist of gravelly sands, sandy silts and clayey silts. Reference should be made to the Record of Borehole sheets for boundary elevations of the different soil types. All field and laboratory test results are plotted on these sheets. The locations and elevations of the borings together with the stratigraphical sections are shown on Drawing No. 2. A brief description of the encountered deposits is given below.

### Gravelly Sands to Sandy Gravels:

The surficial layer in every borehole was identified to be a granular deposit of gravelly sands to sandy gravels with traces of silt. The thickness of the stratum varies between 4.9m and 8.5m. The uppermost 0.9 - 1.2m of the material is usually compact, with penetration "N" values of 10-16 blows per 0.3m beneath which the relative density increases rapidly, "N" values being near and above 100 blows per 0.3m at the east side. On the west side, the penetration resistances were recorded to be somewhat less, averaging around 45 - 50 blows per 0.3m. The natural moisture contents of the samples decrease with depth being around 20% near the surface and some 8-9% farther down. Several grain-size analyses were implemented on representative samples, and they yielded 4 - 61% gravel, 32 - 92% sand and 2 - 22% silt size particles.

### Silty Sand to Sandy Silt, Some Gravel and Clay:

Underlying the gravelly sands around elevation 246.3-249.9 a 2.1 - 4.6m thick layer of silty sand and sandy silt stratum was noted. In a few samples the material contained traces of clay and gravel, but generally it is of a uniform nature, with rather steep grain-size curves. The relative density of this deposit ranges from compact to very dense, corresponding to penetration resistances between 16 blows per 0.3m and 74 blows per 0.3m. Due to the uniform grain-size distribution of this cohesionless material it was felt that the low "N" values might have been caused by the uplift pressure of the unbalanced groundwater head.

### Clayey Silt With Some Sand:

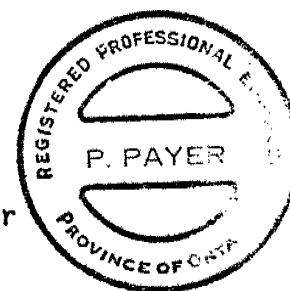
Between elevation 242.3m and 247.8m the sandy silts gradually become cohesive, containing some 23 - 37% clay size particles. Some traces of sand were also present in the samples tested. In a few locations the sand was noticed to form thin horizontal seams within the cohesive layer. The natural moisture content

within this stratum usually lies in between the plastic and the liquid limits and occasionally above the liquid limit. The plastic limit moisture content ranges from 14% to 16% and the liquid limit from 24% to 30%. The average laboratory and field undrained shear strength may be taken to be 96KPa, the mean bulk density being  $21\text{KN/m}^3$ . Below elevation 239.3 the consistency of the clayey silt becomes hard, with penetration resistances of 50 blows per 0.3m and over.

Groundwater Conditions:

The equilibrium groundwater levels in the boreholes were established at elevation 254.2 - 254.5m some 0.6 - 0.9m below ground level. On account of the high water level, in some locations unstable conditions were observed in the borings, within the uniform sandy silt to silty sand layer. The relatively low penetration resistances were considered to be due to the uplift pressure of this unbalanced hydrostatic head.

*P. Payer*  
P. Payer, P. Eng.  
Foundations Engineer



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



# RECORD OF BOREHOLE No 1

METRIC

W P 161-60-01 LOCATION Sta. 9+958.7, o/s 19.2 m Lt. & Co. Rd. 16 Rev. ORIGINATED BY PK  
DIST 4 HWY 403 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RS  
DATUM Geodetic DATE 1972 01 23 CHECKED BY RS

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100								WATER CONTENT (%)			
								SHEAR STRENGTH								10 20 30			
							○ UNCONFINED      + FIELD VANE												
							● QUICK TRIAXIAL      × LAB VANE												
255.5	Ground Level														GR SA S1 CL				
0.0	Gravelly Sand, Traces of Silt		1	SS	15										0 74 17 9				
	Compact to Very Dense		2	SS	103/	229 mm	254								18 77 (5)				
	Brown and Grey		3	SS	102														
			4	SS	100/	229 mm	252								41 53 (6)				
			5	SS	100/	229 mm													
			6	SS	100/	127 mm	250												
248.3			7	SS	33														
7.2	Sandy Silt, Trace of Clay					248													
246.7	Compact		8	SS	18														
8.8	End of Borehole																		

+<sup>3</sup>, x<sup>5</sup>: Numbers refer to  
Sensitivity

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



RECORD OF BOREHOLE No 2

METRIC

W P 161-60-01 LOCATION Sta. 9+976.7; o/s 9.4 m Lt. & Co. Rd. 16 Rev. ORIGINATED BY PK  
DIST 4 HWY 403 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RS  
DATUM Geodetic DATE 1972 01 25 CHECKED BY RS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100							SHEAR STRENGTH		WATER CONTENT (%)	
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    x LAB VANE							10 20 30			
255.4	Ground Level																	
0.0	Sandy Gravel to Gravelly Sand, Traces of Silt		1	SS	16		254											
	Compact to Very Dense		2	SS	23													
	Brown and Grey		3	SS	40													
			4	SS	100			203 mm	252								47 46 (7) 35 56 (9)	
			5	SS	100													
			6	SS	100			102 mm	250								13 85 (2)	
			7	SS	100			152 mm	248									
246.9																		
8.5	Sandy Silt becoming Clayey Silt		8	SS	17		246							0 13 80 7				
	Very Stiff																	
245.0			9	SS	26									0 3 74 23				
10.4	End of Borehole																	

+<sup>3</sup>, x<sup>5</sup>: Numbers refer to  
Sensitivity

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

OFFICE REPORT ON SOIL EXPLORATION





RECORD OF BOREHOLE No 3

METRIC

W P 16I-60-01 LOCATION Sta. 9+971.0, o/s 9.4 m Rt. of Co. Rd. 16 Rev. ORIGINATED BY PK  
DIST 4 HWY 403 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RS  
DATUM Geodetic DATE 1972 01 24 CHECKED BY RS

SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ KN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES	20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>	
255.0	Ground Level													
0.0	Gravelly Sand, Traces of Silt		1	SS	10									
	Compact to Very Dense		2	SS	47									43 50 (7)
			3	SS	74									
			4	SS	100									
			5	SS	100									
250.1														
4.9	Silty Sand													
	Very Dense		6	SS	74									1 56 41 2
248.0	Grey		7	SS	37									0 23 54 23
7.0	Clayey Silt with some Sand													
	Very Stiff to Hard		8	SS	21									
	Grey		9	SS	19									
			10	TW	PH									
			11	SS	39									0 2 68 30
			12	SS	45									
238.5			13	SS	38									0 14 63 23
16.5	End of Borehole													

+3, x5: Numbers refer to  
Sensitivity

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

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 4

METRIC

W P 161-60-01 LOCATION Sta. 9+988.9, o/s 19.2 m Rt. 6 Co. Rd. 16 Rev. ORIGINATED BY PK  
DIST 4 HWY 403 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RS  
DATUM Geodetic DATE 1972 01 20 & 21 CHECKED BY RS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40						60	80	100	WATER CONTENT (%)		
								SHEAR STRENGTH							10	20	30			
255.1	Ground Level													GR SA SI CL						
0.0	Gravelly Sand with some Silt		1	SS	14		254							29 42 24 5						
	Compact to Very Dense		2	SS	61		252								28 65 (7)					
	Brown and Grey		3	SS	47															
			4	SS	29															
			5	SS	49										28 50 (22)					
			6	SS	38															
			7	SS	170		229 mm	248												
246.4			8	SS	28									2 81 (17)						
8.7	Silty Sand to Sandy Silt, Some Gravel and Clay		9	SS	54		246													
	Dense to Very Dense		10	SS	42		244							25 23 41 11						
242.6																				
12.5	Clayey Silt with some Sand		11	SS	28		242													
	Very Stiff to Hard		12	SS	35		240							0 4 62 34						
	Grey		13	SS	32		238													
			14	SS	31		236													
			15	SS	61															
			16	SS	100	203 mm	234							8 10 68 14						
			17	SS	100	152 mm														
231.5							232													
23.6	End of Borehole																			

+3, x5: Numbers refer to  
Sensitivity

20  
15 ± 5 (%) STRAIN AT FAILURE  
10

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 5

METRIC

W P: 161-60-01 LOCATION Sta. 10+011.0, o/s 19.2 m Lt. & Co. Rd. 16 Rev. ORIGINATED BY PK  
DIST 4 HWY 403 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY RS  
DATUM Geodetic DATE 1972 01 14 CHECKED BY RS

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE								
255.1	Ground Level											
0.0	Sandy Gravel to Gravelly Sand		1	SS	18							
	Traces of Silt		2	SS	22							
	Compact to Very Dense		3	SS	100/279							
	Brown and Grey		4	SS	108/254							
			5	SS	140/51							
			6	SS	102/203							
			7	SS	100/178							
246.6												
8.5	Clayey Silt, Trace of Sand		8	SS	26							
246.0			9	TV	PH							
9.1	End of Borehole											

+3, x<sup>5</sup>: Numbers refer to Sensitivity

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

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 6

METRIC

W P 161-60-01 LOCATION Sta. 10+029.1; o/s 9.4 m Lt. & Co. Rd. 16 Rev. ORIGINATED BY PK  
DIST 4 HWY 403 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RS  
DATUM Geodetic DATE 1972 01 17 CHECKED BY RS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
255.0	Ground Level																
0.0	Gravelly Sand, Traces of Silt		1	SS	8		254										
	Loose to Very Dense		2	SS	22												19 75 (6)
	Brown and Grey		3	SS	55												
			4	SS	87		252										
			5	SS	90												
249.3			6	SS	33		250										
5.7	Clayey Silt with Traces of Sand and Gravel		7	TW	PH											20.6	4 8 63 23
	Random Seams of Fine Sand		8	SS	35		248										0 15 51 34
	Hard		9	SS	41		246										
	Grey		10	SS	26											21	
			11	TW	PH		244										
			12	TW	PH											21	0 2 64 34
			13	TW	PH		242										
			14	TW	PH		240									20.9	
			15	SS	90												2 7 58 33
237.0			16	SS	94		238										
18.0	End of Borehole																

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 7

METRIC

W P 161-60-01 LOCATION Sta. 10+023.2; o/s 9.4 m Rt. of Co. Rd. 16 Rev. ORIGINATED BY PK  
DIST 4 HWY 403 BOREHOLE TYPE Hollow Stem Auger COMPILED BY RS  
DATUM Geodetic DATE 1972 01 18 CHECKED BY RS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
255.0	Ground Level																
0.0	Gravelly Sand, Traces of Silt		1	SS	24		254										
	Compact to Very Dense		2	SS	31												39 57 (4)
			3	SS	44		252										36 55 (9)
			4	SS	41												
			5	SS	85												
249.8							250										
5.2	Sandy Silt with some Clay		6	SS	29												0 28 58 14
	Compact		7	SS	16		248										
			8	SS	17		246										
245.1																	
9.9	Clayey Silt, Random Seams of Fine Sand		9	SS	20		244										
	Stiff to Very Stiff		10	TW	PH		242									21	0 0 63 37
			11	TW	PH											21	
239.6			12	TW	PH		240									21.2	
15.4	End of Borehole																

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

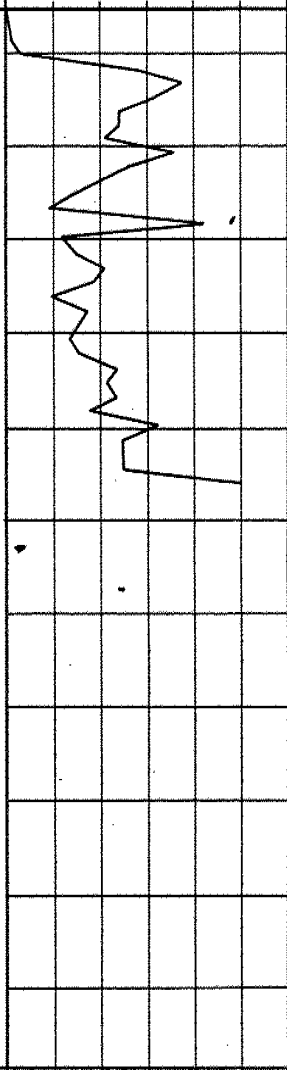
OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 8

METRIC

W P 161-60-01 LOCATION Sta. 10+041.1; o/s 19.2 m Rt. & Co. Rd. 16 Rev. ORIGINATED BY PK  
DIST 4 HWY 403 BOREHOLE TYPE Hollow Stem Auger and Cone Test COMPILED BY RS  
DATUM Geodetic DATE 1972 01 18 & 19 CHECKED BY RS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100						WATER CONTENT (%)
254.9	Ground Level												GR SA SI CL	
0.0	Gravelly Sand, Traces of Silt	•••••	1	SS	15							28 67 (5)		
	Compact to Very Dense		2	SS	85									
			3	SS	27									
			4	SS	47									
			5	SS	17									
249.4														0 64 31 5
5.5	Silty Sand, Traces of Clay	6	SS	27										
	Compact	7	SS	27									3 10 57 30	
247.1														
7.8	Clayey Silt, Traces of Sand and Gravel	8	SS	24										
	Very Stiff to Hard	9	SS	25										
		10	SS	23										
		11	SS	46										
		12	SS	37										
239.1														
15.8	Sandy Silt with some Clay	13	SS	53										
	Very Dense	14	SS	78										
		15	SS	100/152 mm										
		16	SS	54									0 40 51 9	
232.3		17	SS	52										
22.6	End of Borehole													

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

OFFICE REPORT ON SOIL EXPLORATION



15

## METRIC

W P 161-60-01 LOCATION Sta. 9+972.5; o/s 19.2 m Lt. of Co. Rd. 16 Rev. ORIGINATED BY PK  
DIST 4 HWY 403 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY RS  
DATUM Geodetic DATE 1972 01 24 CHECKED BY RS

SOIL PROFILE		SAMPLES				GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100			W <sub>p</sub>
255.6	Ground Level														
0.0															
253.2							254								
2.4	End of Cone Test										100/	279			

<sup>+</sup><sub>3</sub>, x<sup>5</sup> : Numbers refer to Sensitivity

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

OFFICE REPORT ON SOIL EXPLORATION

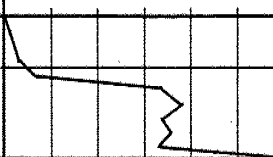




## RECORD OF BOREHOLE No 11

METRIC

W P 161-60-0 LOCATION Sta. 9+984.7; o/s 9.4 m Rt. of Co. Rd. 16 Rev. ORIGINATED BY PK  
DIST 4 HWY 403 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY RS  
DATUM Geodetic DATE 1972 01 24 CHECKED BY RS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT $W_p$	NATURAL MOISTURE CONTENT $W$	LQUID LIMIT $W_L$	UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE		WATER CONTENT (%)			
255.1 0.0	Ground Level						254						
252.1 3.0	End of Cone Test									120/ 203 mm			

+3, x5 : Numbers refer to Sensitivity

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

OFFICE REPORT ON SOIL EXPLORATION



18

**METRIC**

W P 161-60-0 LOCATION Sta. 9+975.2; o/s 19.2 m Rt. 6 Co. Rd. 16 Rev. ORIGINATED BY PM  
DIST 4 HWY 403 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY RS  
DATUM Geodetic DATE 1972 01 24 CHECKED BY RS

[illegible]

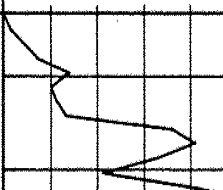
+3, x5: Numbers refer to Sensitivity

OFFICE REPORT ON SOIL EXPLORATION



**METRIC**

W P	161-60-01	LOCATION	Sta. 10+024.7; o/s 19.2 m Lt. & Co. Rd. 16 Rev.	ORIGINATED BY	PK
DIST	4 HWY 403	BOREHOLE TYPE	Dynamic Cone Penetration Test	COMPILED BY	RS
DATUM	Geodetic	DATE	1972 01 13	CHECKED BY	RS

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100	W <sub>p</sub>	W		
255.3	Ground Level						SHEAR STRENGTH ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    x LAB VANE	WATER CONTENT (%)			γ	GR SA SI CL
0.0						254						
251.4						252						
3.9	End of Cone Test											

+3, x<sup>5</sup>: Numbers refer to Sensitivity

OFFICE REPORT ON SOIL EXPLORATION



RECORD OF BOREHOLE No 14

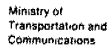
METRIC

W P 161-60-01 LOCATION Sta. 10+015.3; o/s 9.4 m Lt. & Co. Rd. 16 Rev. ORIGINATED BY PK  
DIST 4 HWY 403 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY RS  
DATUM Geodetic DATE 1972 01 13 CHECKED BY RS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES									
255.0	Ground Level						254							
0.0														
252.5														
2.5	End of Cone Test													

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE



## METRIC

W P 161-60-01 LOCATION Sta. 10+036.5: o/s 9.4 m Br. & Co. Rd. 16 Rev. ORIGINATED BY PK  
DIST 4 HWY 403 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY RS  
DATUM Geodetic DATE 1972 01 13 CHECKED BY \_\_\_\_\_

+3, x5: Numbers refer to Sensitivity

OFFICE REPORT ON SOIL EXPLORATION



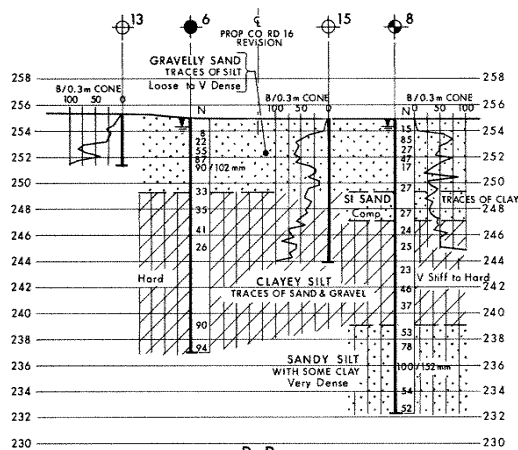
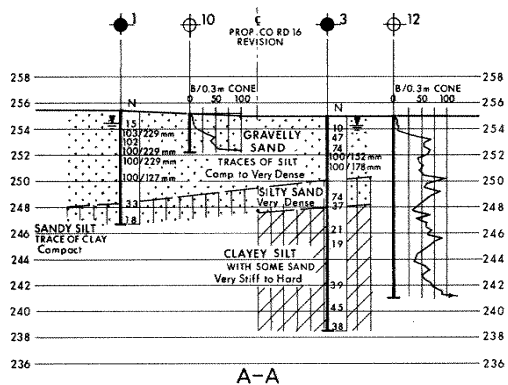
## METRIC

W P 161-60-01 LOCATION Sta. 10+027.4; o/s 19.2 m Rt. of Co. Rd. 16 Rev. ORIGINATED BY PK  
DIST 4 HWY 403 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY RS  
DATUM Geodetic DATE 1972 01 13 CHECKED BY RS

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT	PLOT	NUMBER			TYPE	'N' VALUES					
254.8	Ground Level						SHEAR STRENGTH ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE		WATER CONTENT (%)				
0.0						254							
250.9						252							
3.9	End of Cone Test												

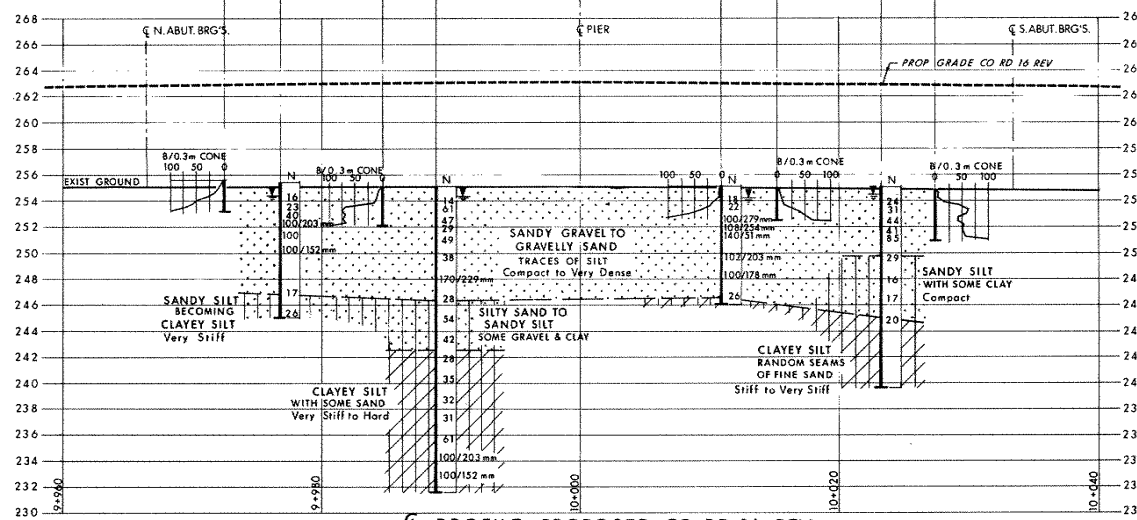
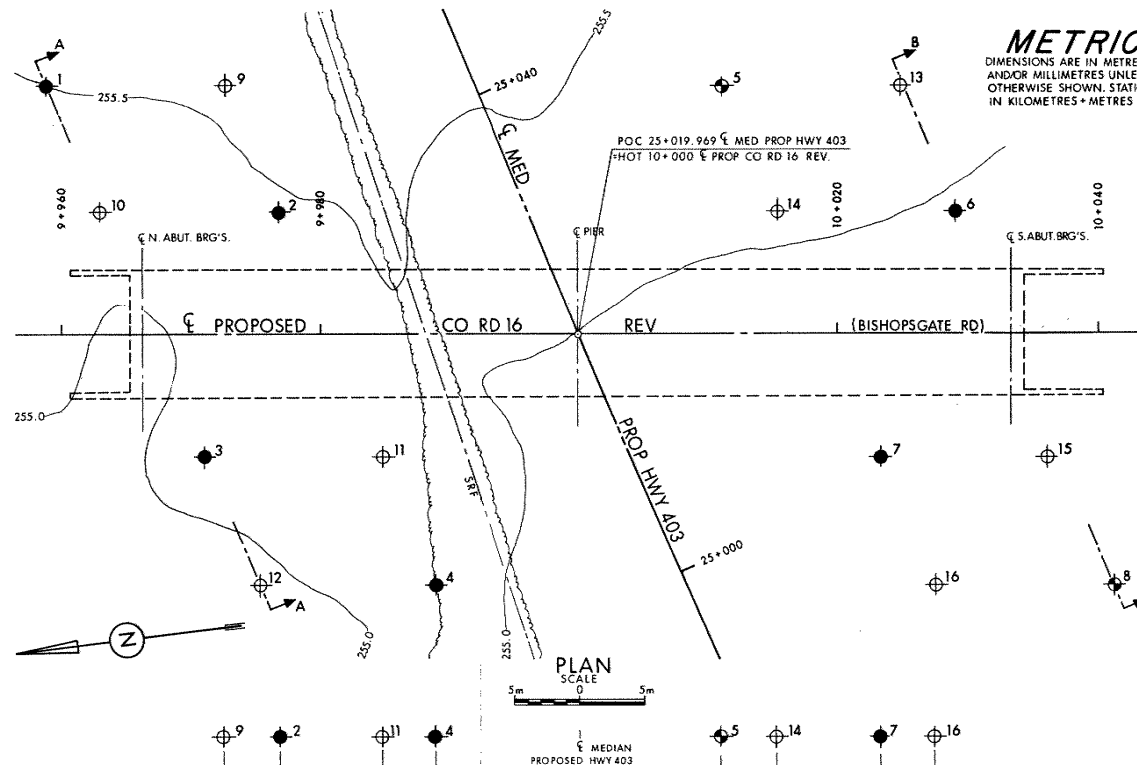
+3, x5: Numbers refer to Sensitivity

OFFICE REPORT ON SOIL EXPLORATION



B-B  
SECTIONS

HOR 10m 5 10m  
VERT 5m 2.5 0 5m

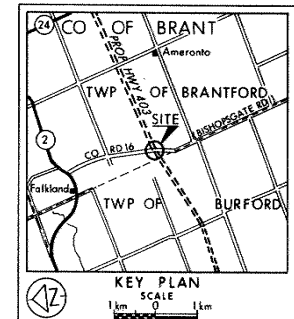


PROFILE-PROPOSED CO RD 16 REV

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

CONT No 81-43  
WP No 161-60-01  
PROP CO RD 16 REV U.PASS  
(3.9 km W of Hwy 24A)  
BORE HOLE LOCATIONS & SOIL STRATA

SHEET  
156



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)			
⬇	WL at time of investigation 1972-01			

No	ELEVATION	STATION	OFFSET CO RD 16 REV
1	255.5	9+958.7	19.2m LT
2	255.4	9+976.7	9.4m LT
3	255.0	9+971.0	9.4m RT
4	255.1	9+988.9	19.2m RT
5	255.1	10+011.0	19.2m LT
6	255.0	10+029.1	9.4m LT
7	255.0	10+023.2	9.4m RT
8	254.9	10+041.1	19.2m RT
9	255.6	9+972.5	19.2m LT
10	255.2	9+975.2	9.4m LT
11	255.1	9+984.7	9.4m RT
12	255.0	9+975.2	19.2m RT
13	255.3	10+024.7	19.2m LT
14	255.0	10+015.3	9.4m LT
15	254.9	10+036.5	9.4m RT
16	254.8	10+027.4	19.2m 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.

REVISIONS	DATE	BY	DESCRIPTION

Geocres No 40P1-53			
HWY No 403	DATE 1980 01 17	SITE 1-155	DIST 4
SUBWD K S CHECKED	APPROVED		
DRAWN R S CHECKED			DWG 2

REF No E-5547-1, 1979 04

## DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS

## MEMORANDUM

TO: Mr. G. C. E. Burkhardt, (2) FROM: Foundations Office,  
Regional Bridge Planning Engineer, Design Services Branch,  
Central Region, Central Bldg., Downsview.  
90 Floral Parkway,  
ATTENTION: Downsview, Ontario. DATE: March 23, 1972

OUR FILE REF.

IN REPLY TO

APR 21 1972

SUBJECT:

40 P1-53

GEOCRES No.

## FOUNDATION INVESTIGATION REPORT

For

The Overhead Structure of Proposed C.A.R. #403  
Line "E", and Revised County Rd. #16  
6.2 Mi. West of Brantford West Limits  
District #4 (Hamilton)  
W.O. 71-11108 -- W.P. 161-60-00

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.

AGS/ao  
Attach.

*A. G. Sternac*  
A. G. Sternac,  
PRINCIPAL FOUNDATION ENGINEER.

cc: Messrs. D. W. Farren  
B. R. Davis  
A. Rutka  
G. K. Hunter  
C. R. Robertson  
B. J. Giroux  
T. J. Kovich  
G. A. Wong  
B. A. Singh

Foundations Files  
Documents



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1. INTRODUCTION.
  2. DESCRIPTION OF THE SITE AND GEOLOGY.
  3. FIELD AND LABORATORY INVESTIGATIONS.
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    - 4.3) Silty Sand to Sandy Silt, Some Gravel and Clay.
    - 4.4) Clayey Silt With Some Sand.
    - 4.5) Groundwater Conditions.
  5. DISCUSSION AND RECOMMENDATIONS.
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    - 5.2) Foundations.
      - 5.2.1) Abutments.
      - 5.2.2) Piers.
    - 5.3) Approach Fills.
  7. MISCELLANEOUS.
-

FOUNDATION INVESTIGATION REPORT  
For  
The Overhead Structure of Proposed C.A.H. #403  
Line "E", and Revised County Rd. #16  
6.2 Mi. West of Brantford West Limits  
District #4 (Hamilton)  
W.O. 71-11108      --      W.P. 161-60-00

---

1. INTRODUCTION:

A foundation investigation for the proposed overhead of C.A.H. #403 Line "E" at the revised County Rd. #16 was requested by Mr. A. P. Watt, Regional Bridge Planning Engineer, Southwestern Region. The memo containing the request was dated September 23, 1971.

Accordingly, a field and subsequent laboratory investigation was carried out under the supervision of this Office. The boreholes were located and surveyed in the field by personnel of the Engineering Survey Office, Southwestern Region.

Presented in this report are the results of the investigations together with discussions and recommendations pertaining to foundations and related problems.

2. DESCRIPTION OF THE SITE AND GEOLOGY:

The terrain at the bridge site is relatively flat farmland, used mainly for crops. There are some small woods in the vicinity and some swampy areas farther to the south.

Geologically the site is part of the physiographic region known as the Norfolk Sand Plain. The sands and silts of this region were deposited as a delta in glacial lakes Whittlesey and Warren. The sand beds are usually followed within 30 feet of the surface by silts and clays. The sands in the intermorainal and other interfluvial sections of the plain are rather wet, for the lack of proper drainage.

### 3. FIELD AND LABORATORY INVESTIGATIONS:

Some eight boreholes and eight dynamic cone penetration tests were carried out in the field, holes being placed at the locations of the proposed footings. Soil sampling was implemented by means of split-spoons and 2-inch diameter Shelby Tubes at regular intervals. Dynamic and standard penetration tests were performed by a 140 lbs. drop hammer falling freely a distance of 30 inches. The number of hammer blows required to advance the standard split-spoon sampler 1 ft. into the soil is specified as penetration "N" value. Shelby tube samples were taken within the cohesive strata by pushing the tubes hydraulically 18 inches into the undisturbed soils.

Visual examinations and identifications of the samples were carried out after recovery and again upon arrival in the laboratory.

The physical properties of the soil specimens were determined in the laboratory by performing tests such as natural moisture contents, Atterberg limits and grain-size analysis. The undrained shear parameters of the cohesive layer were measured by means of unconfined compression and field vane tests.

The locations and elevations of the boreholes are marked on Drawing #71-11108A in the Appendix together with the stratigraphical sections at the footing locations. All the field and laboratory test results are plotted on the attached borelog sheets.

### 4. SOIL CONDITIONS:

#### 4.1) General:

Subsoil at the site was found to consist of gravelly sands, sandy silts and clayey silts, generally of dense to very dense relative density and very stiff to hard consistency. A brief description of the deposits is given below.

4.2) Gravelly Sands to Sandy Gravels:

The surficial layer in every borehole was identified to be a granular deposit of gravelly sands to sandy gravels with traces of silt. The thickness of the stratum varies between 16 ft. and 28 ft. The uppermost 3-4 ft. of the material is usually compact, with penetration "N" values of 10-16 blows per ft. beneath which the relative density increases rapidly, "N" values being near and above 100 blows per ft. at the east abutment and east pier locations. Under the west pier and west abutment, penetration resistances were recorded to be somewhat less, averaging around 45-50 blows per ft. The natural moisture contents of the samples decrease with depth being around 20% near the surface and some 8-9% farther down. Several grain-size analyses were implemented on representative samples, and they yielded 4-61% gravel, 32-92% sand and 2-22% silt size particles.

4.3) Silty Sand to Sandy Silt, Some Gravel and Clay:

Underlying the gravelly sands around elevation 806-820 ft. a 7-15 ft. thick layer of silty sand and sandy silt stratum was noted. In a few samples the material contained traces of clay and gravel, but generally it is of a uniform nature, with rather steep grain-size curves. The relative density of this deposit ranges from compact to very dense, corresponding to penetration resistances between 16 blows per ft. and 74 blows per ft. Due to the uniform grain-size distribution of this cohesionless material it was felt that the low "N" values might have been caused by the uplift pressure of the unbalanced groundwater head.

4.4) Clayey Silt With Some Sand:

Between elevation 795 ft. and 813 ft. the sandy silts gradually become cohesive, containing some 23-37% clay size particles. Some traces of sand were also present in the samples tested. In a few locations the sand was noticed to

form thin horizontal seams within the cohesive layer. The natural moisture content within this stratum usually lies in between the plastic and the liquid limits and occasionally above the liquid limit. The plastic limit moisture content ranges from 14% to 16% and the liquid limit from 24% to 30%. The average laboratory and field undrained shear strength may be taken to be 2000 p.s.f., the mean bulk density being 134 p.c.f. Below elevation 785 ft. the consistency of the clayey silt becomes hard, with penetration resistances of 50 blows per ft. and over.

#### 4.5) Groundwater Conditions:

The equilibrium groundwater levels in the boreholes were established at elevation 834-835 ft. some 2-3 ft. below ground level. On account of the high water level, in some locations unstable conditions were observed in the borings, within the uniform sandy silt to silty sand layer. The relatively low penetration resistances were considered to be due to the uplift pressure of this unbalanced hydrostatic head.

### 5. DISCUSSION AND RECOMMENDATIONS:

#### 5.1) General:

It is proposed to build a twin overpass structure for the future C.A.H. #403, Line "E" at the crossing of Grant County Rd. #16 Revision. The County Rd. will be improved to four lanes. The grade of C.A.H. #403 at the crossing is designed to be at elev. 860 ft. with approach fills of 22-25 ft. height. It is assumed that the bridge will be built with spill through type abutments.

Subsoil at the footing locations consists of gravelly sands and silty sands of compact to very dense relative density, underlain by clayey silts of stiff to hard consistency.

## 5.2) Foundations:

### 5.2.1) Abutments:

The most economical foundation for the abutments appears to be the one supported on piles, the pile caps being formed within the approach embankments. The use of 12-3/4 O.D. steel tubes of 1/4 inch wall thickness is suggested, driven to 70 ton per pile capacity as determined by the Hiley formula, (DTC Standard DD-1218-1219). It is estimated that at the location of the east abutment 70 ton per pile design load may be reached by driving the piles through the fill and some 10 ft. into the original soil (tip elevation approx. 827 ft. - 828 ft).

Soil conditions at the location of the west abutment, however, were found to be less favourable, thus considerably longer piles will be required to achieve the suggested design loads. It is estimated that piles, below the west abutment might be driven to elevation 765 ft. - 775 ft. (some 60-70 ft. below existing ground level) in order to mobilize 70 ton per pile safe pressures. It is again emphasized that the working load on the piles should be checked during pile driving by the use of the Hiley formula. The approach fills should be devoid of bouldery material at the locations of the abutments to alleviate pile driving.

### 5.2.2) Piers:

Both the east and west piers may most economically be designed on spread footings; the base of the footings being at or below elevation 832 ft. Safe design loads of 2.5 t.s.f. may be employed on the footings, placed at the suggested elevations.

The groundwater level at the time of the field investigations was recorded to be at elevation 834 ft. - 835 ft. some 2-3 ft. above the recommended footing bases. On account of the granular nature of the soil, it is anticipated that some quick conditions may occur at the bottom of the excavations,

caused by the unbalanced hydrostatic head. To eliminate "boiling" of the excavations, a dewatering scheme will be necessary

5.3) Approach Fills:

No stability problems are expected for the proposed 22-25 ft. high approach fills, provided that they are constructed with 2 horizontal to 1 vertical slopes.

6. MISCELLANEOUS:

The field work carried out during the period of January 14-25, 1972, was supervised by Mr. P. Korgemagi, Project Foundation Engineer.

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

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

*A. K. Barsvary*

A. K. Barsvary, P. Eng.

*K. G. Selby*

K. G. Selby, P. Eng.

AKB/ao  
March 21, 1972.



APPENDIX I





DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS

DESIGN SERVICES BRANCH

## RECORD OF BOREHOLE No. 2

FOUNDATION SECTION

JOB 71-11108

LOCATION Sta. 2 + 64 o/s 58' Mt. 2 Line 'E'

ORIGINATED BY PK

W.P. 161-60-00

BORING DATE Jan. 25, 1972

COMPILED BY PK

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger

CHECKED BY *SR*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT				LIQUID LIMIT — $w_L$ PLASTIC LIMIT — $w_p$ WATER CONTENT — $w$			BULK DENSITY $\gamma$ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PT.	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.				WATER CONTENT %				
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE				$w_p$ — $w$ — $w_L$ 10 20 30				
838.0	Ground Level														
0.0	Sandy gravel to gravelly sand, traces of silt.		1	SS	16	830									47 46 ( 7 ) 35 56 ( 9 )
			2	SS	23										
			3	SS	20										
			4	SS	100/134"										
			5	SS	100										
	Compact to Very Dense  Brown and Gray		6	SS	100/71"	820									13 85 1 2 1
			7	SS	100/6"										
810.2															
27.8	Sandy silt becoming clayey silt.		8	SS	17	810									0 13 80 7
801.0	Very Stiff		9	SS	26										0 3 74 23
34.0	End of Borehole					800									

47 46 ( 7 )

35 56 ( 9 )

13 85 1 2 1

0 13 80 7

0 3 74 23

DESIGN SERVICES BRANCH

## RECORD OF BOREHOLE No. 3

FOUNDATION SECTION

JOB 71-11108

LOCATION Sta. 3+14 o/s 100' Rt. C Line 'E'

ORIGINATED BY PK

W.P. 161-60-00

BORING DATE Jan. 24, 1972

COMPILED BY PK

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger

CHECKED BY                     

[illegible]

## DESIGN SERVICES BRANCH

## RECORD OF BOREHOLE No. 4

FOUNDATION SECTION

JOB 71-11108

LOCATION Sta. 3 + 66 o/s 58' Rt. of Line 'B'

ORIGINATED BY PK

W.P. 161-60-00

BORING DATE Jan. 20, 1972 and Jan. 21

COMPILED BY PK

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger

CHECKED BY PK

SOIL PROFILE		SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT				LIQUID LIMIT — $w_L$ PLASTIC LIMIT — $w_p$ WATER CONTENT — $w$				BULK DENSITY $\gamma$ P.C.F.	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		BLOWS / FOOT	SHEAR STRENGTH P.S.F.				WATER CONTENT %					
							<div><div>○ UNCONFINED</div><div>● QUICK TRIAXIAL</div><div>+ FIELD VANE</div><div>x LAB. VANE</div></div>				<div><div><math>w_p</math> — <math>w</math> — <math>w_L</math></div><div>10 20 30</div></div>					
836.8	Ground Level														GR. SA. SI. CL.	
0.0	Gravelly sand with some silt.  Compact to Very Dense  Brown and Grey		1	SS	14	830									29 42 24 5	
			2	SS	61										28 65 ( 7 )	
			3	SS	47											
			4	SS	29											
			5	SS	49										28 50 (22)	
			6	SS	38											
			7	SS	170/9"											
808.2	Silty sand to sandy silt, some gravel and clay.  Dense to Very Dense		8	SS	28	810									2 81 (17)	
28.6			9	SS	54										25 23 41 11	
			10	SS	42	800										
795.8	Clayey silt with some sand.  Very Stiff to Hard.  Grey		11	SS	28	790									0 4 62 34	
41.0			12	SS	35											
			13	SS	32											
			14	SS	31		780									
			15	SS	61										8 10 68 14	
			16	SS	100/8"		770									
			17	SS	100/6"											
759.3	End of Borehole					760										
77.5							750									

## RECORD OF BOREHOLE No. 5

FOUNDATION SECTION

JOE 71-11108

LOCATION Sta. 2 + 77 o/s 58' Lt. E Line 'E'

ORIGINATED BY FK

W.P. 161-60-00

BORING DATE Jan. 11, 1972

COMPILED BY       /ER      

DATUM Geodetic

BOREHOLE TYPE Full Stem Auger

CHECKED BY  PAGE 1

[illegible]

DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS  
DESIGN SERVICES BRANCH

# RECORD OF BOREHOLE No. 6

FOUNDATION SECTION

JOB 71-11108 LOCATION Sta. 3 + 30 o/s 100' Lt. @ Line 'E' ORIGINATED BY PK  
W.P. 161-60-00 BORING DATE Jan. 17, 1972 COMPILED BY PK  
DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY *[Signature]*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — $w_L$ PLASTIC LIMIT — $w_p$ WATER CONTENT — $w$			BULK DENSITY Y P.C.F.	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.		WATER CONTENT %					
							1000	2000	10	20	30			
836.7	Ground Level													
0.0	Gravelly sand, traces of silt.  Loose to Very Dense	•••••	1	SS	8									
			2	SS	22									
			3	SS	55									
			4	SS	87									
			5	SS	204									
817.9	Brown and Grey		6	SS	33									
18.8	Clayey silt with traces of sand and gravel.  Random seams of fine sand.  Hard  Grey		7	TW	PH							131	4 8 65 23	
			8	SS	35									0 15 51 34
			9	SS	11									
			10	SS	26								134	
			11	TW	PH								134	0 2 64 34
			12	TW	PH									
			13	TW	PH									
			14	TW	PH								133	
			15	SS	90									2 7 58 33
			16	SS	94									
777.7														
59.0	End of Borehole													

## RECORD OF BOREHOLE No. 7

FOUNDATION SECTION

JOH 71-113.08

LOCATION Sta. 3 + 80 o/s 58' Lt. of Line 1B'

ORIGINATED BY           FE          

W.P. 162-60-00

BORING DATE Jan. 18, 1972

COMPILED BY                      FILE 7

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Auger

CHECKED BY                     

SOIL PROFILE			SAMPLES	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT	Liquid Limit ———— W <sub>L</sub> Plastic Limit ———— W <sub>P</sub> Water Content ———— W	BULK DENSITY $\gamma$	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. LOT	NUMBER	TYPE	BLOWS / FOOT	SHEAR STRENGTH P.S.F.	WATER CONTENT %	P.C.F.
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE	10 20 30	
						1000 2000		
836.5	Ground Level							
0.0	Gravelly sand, traces of silt.		1	SS	21			
			2	SS	31			
			3	SS	41			
	Compact to Very Dense		4	SS	47			
			5	SS	65			
819.5								
17.0	Sandy silt with some clay.		6	SS	29			
			7	SS	16			
	Compact		8	SS	17			
803.9								
32.6	Clayey silt, random seams of fine sand.		9	SS	20			
			10	TN	NH			
			11	TN	NF			
	Stiff to Very Stiff		12	TN	FH			
786.1								
50.1	End of Borehole							

## RECORD OF BOREHOLE No. 8

FOUNDATION SECTION

## DESIGN SERVICES BRANCH

JOB 71-11108

LOCATION

Sta. 4 + 32 o/s 100' Lt. E Line 'E'

ORIGINATED BY IK

W.P. 161-60-00

BORING DATE

Jan. 18 and 19, 1972

COMPILED BY PK

DATUM Geodetic

BOREHOLE TYPE

Hollow Stem Auger

CHECKED BY

SOIL PROFILE		SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT		LIQUID LIMIT — $w_L$ PLASTIC LIMIT — $w_p$ WATER CONTENT — $w$		BULK DENSITY $\gamma$ P.C.F.	REMARKS							
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		20	40	60	80			100	10	20	30			
836.3	Ground Level																	
0.0	Gravelly sand, traces of silt.  Compact to Very Dense		1	SS	15													
			2	SS	85													
			3	SS	27													
			4	SS	47													
			5	SS	17													
818.3			6	SS	27													
18.0	Silty sand, traces of clay.  Compact		7	SS	27													
810.8																		
25.5	Clayey silt, traces of sand and gravel.  Very Stiff to Hard		8	SS	24													
			9	SS	25													
			10	SS	23													
			11	SS	46													
			12	SS	37													
784.3																		
52.0	Sandy silt with some clay.  Very Dense		13	SS	53													
			14	SS	78													
			15	SS	100													
			16	SS	54													
762.3			17	SS	52													
74.0	End of Borehole																	





DEPARTMENT OF TRANSPORTATION AND COMMUNICATIONS

DESIGN SERVICES BRANCH

## RECORD OF BOREHOLE No. 10

FOUNDATION SECTION

JOB 71-11308

LOCATION

Sta. 2+47 o/s 100' Rt. @ Line 'E'

ORIGINATED BY PK

W.P. 161-60-00

BORING DATE

Jan. 24, 1972

COMPILED BY GP

DATUM Geodetic

BOREHOLE TYPE

Cone Test Only

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — $w_L$		BULK DENSITY $\gamma$	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		BLOWS / FOOT	20	40	60	80	100	PLASTIC LIMIT — $w_p$		
837.3	Ground Level						SHEAR STRENGTH P.S.F.					WATER CONTENT %			
0.0							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE					$w_p$ — $w$ — $w_L$			
827.6						830						100/8"			
9.7	End of Cone Test														

[illegible]

## DESIGN SERVICES BRANCH

## RECORD OF BOREHOLE No. 12

### FOUNDATION SECTION

JOB 71-11108

LOCATION Sta. 3 + 49 o/s 100' Rt. 6 Line 'B'

ORIGINATED BY PK

W.P. 161-60-00

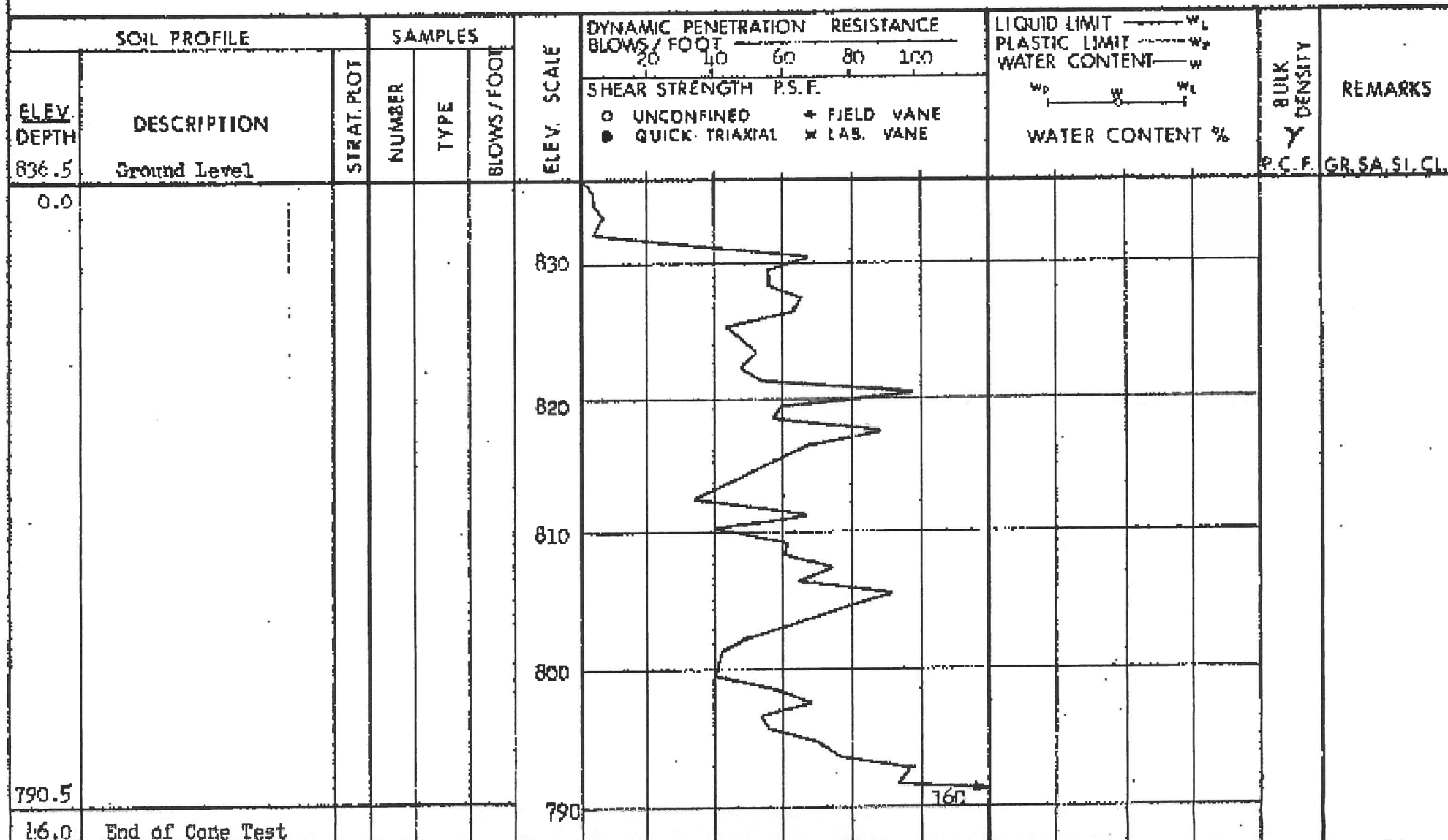
BORING DATE Jan. 24, 1972

COMPILED BY                      GP                     

DATUM Geodetic

BOREHOLE TYPE Core Test Only

CHECKED BY                     



CHECKED BY                     

[illegible]

FOUNDATION SECTION:

ORIGINATED BY PK

COMPILED BY           JCE          

CHECKED BY                     

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE				LIQUID LIMIT _____ W <sub>L</sub>		BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT	20	40	60	80	100		
836.6	Ground Level						SHEAR STRENGTH P.S.F.				W <sub>P</sub> ——— W ——— W <sub>L</sub>			
0.0							○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    x LAB. VANE				WATER CONTENT %			
828.5						830								
8.1	End of Cone Test					820								



### FOUNDATION SECTION

CHECKED BY                     

[illegible]



## 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>γ 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 - 20
STIFF	8 - 15	1000 - 2000	DENSE	20 - 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.B.	WASHED SAMPLE	T.P.	THINWALL PISTON
B.B.	SCRAPER BUCKET SAMPLE	G.S.	DESTERBERG SAMPLE
A.S.	AUDER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE
S.T.	BLOTTED TUBE SAMPLE		

P.H. SAMPLE ADVANCED HYDRAULICALLY

P.M. SAMPLE ADVANCED MANUALLY

### SOIL TESTS

CU	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
U	UNDRAINED TRIAXIAL	F.V.	FIELD VANE
CUU	CONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
QU	DRAINED TRIAXIAL	S	SENSITIVITY

## ABBREVIATIONS USED IN THIS REPORT

### SOIL PROPERTIES

$\gamma$	UNIT WEIGHT OF SOIL (BULK DENSITY)
$\gamma_s$	UNIT WEIGHT OF SOLID PARTICLES
$\gamma_w$	UNIT WEIGHT OF WATER
$\gamma_d$	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
$\gamma'$	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
$\tau_f$	SHEAR STRENGTH
$c'$	EFFECTIVE COHESION INTERCEPT
$\phi'$	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
$c_d$	APPARENT COHESION
$\phi_d$	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
$\mu$	COEFFICIENT OF FRICTION
$S_i$	SENSITIVITY

### GENERAL

$\pi$	$= 3.1416$
$e$	BASE OF NATURAL LOGARITHMS 2.7183
$\log_e \sigma$ OR $\ln \sigma$	NATURAL LOGARITHM OF $\sigma$
$\log_{10} \sigma$ OR $\log \sigma$	LOGARITHM OF $\sigma$ 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
$\sigma$	NORMAL STRESS
$\sigma'$	NORMAL EFFECTIVE STRESS ( $\bar{\sigma}$ IS ALSO USED)
$\tau$	SHEAR STRESS
$\epsilon$	LINEAR STRAIN
$\gamma$	SHEAR STRAIN
$\nu$	POISSON'S RATIO ( $\mu$ IS ALSO USED)
$E$	MODULUS OF LINEAR DEFORMATION (YOUNG'S MODULUS)
$G$	MODULUS OF SHEAR DEFORMATION
$K$	MODULUS OF COMPRESSIBILITY
$\eta$	COEFFICIENT OF VISCOSITY

### EARTH PRESSURE

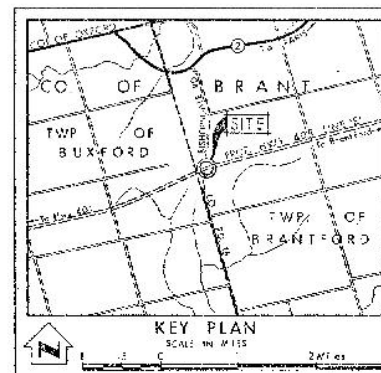
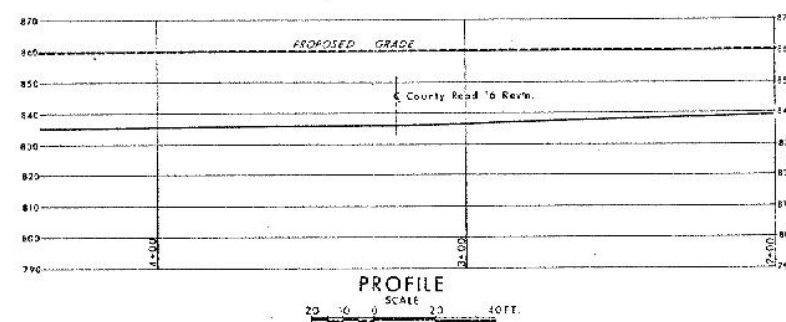
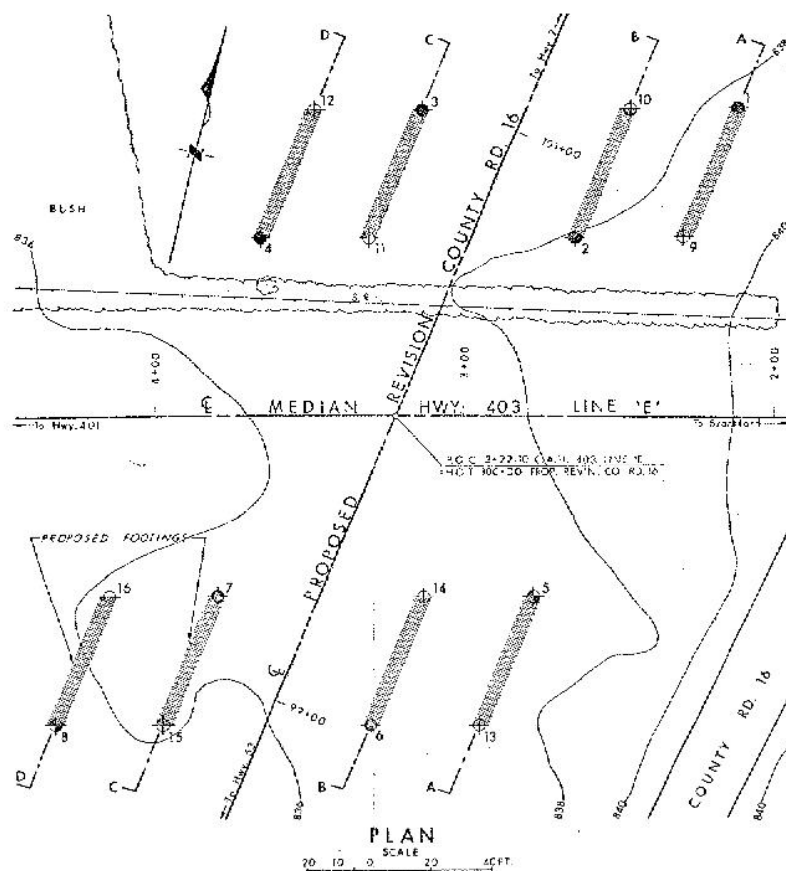
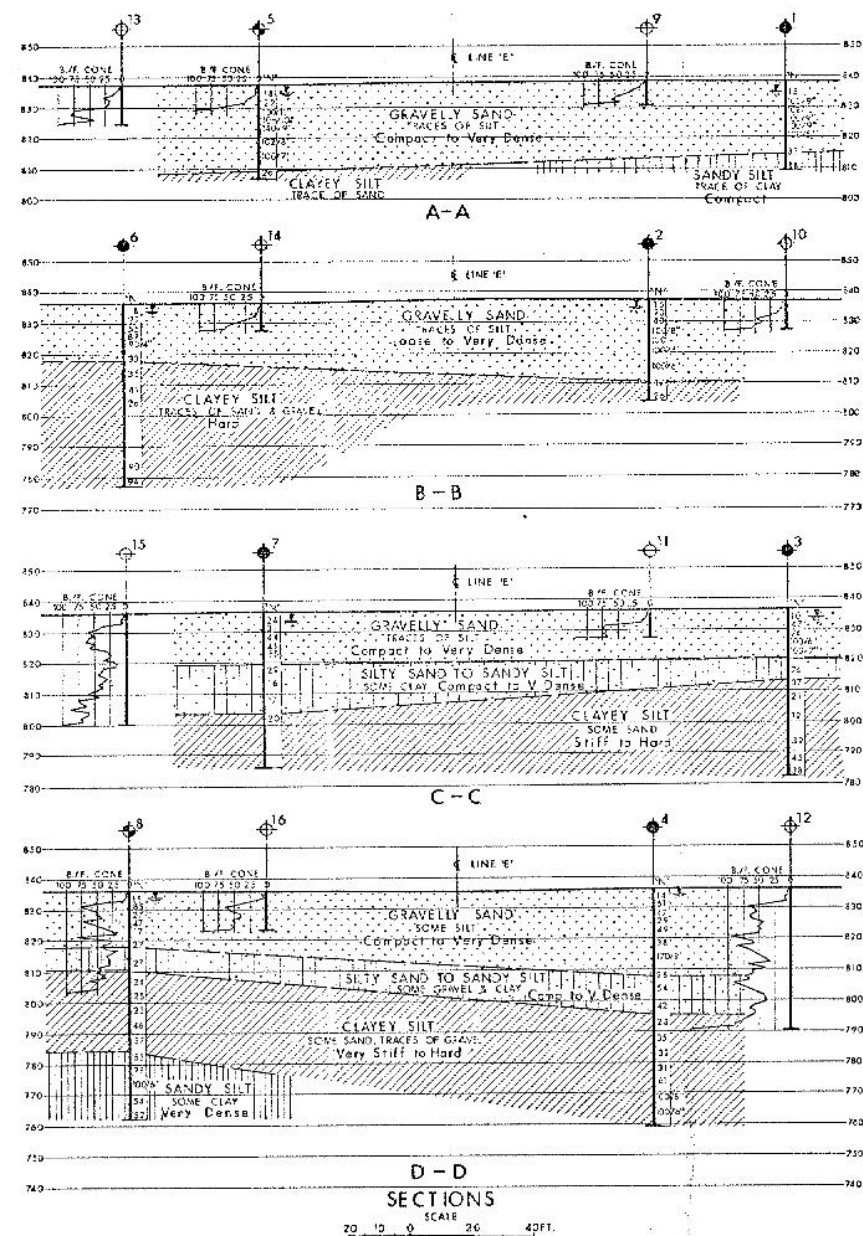
$d$	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
$\delta$	ANGLE OF WALL FRICTION
$K$	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
$K_0$	COEFFICIENT OF EARTH PRESSURE AT REST

### 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
$\beta$	ANGLE OF SLOPE TO HORIZONTAL



LEGEND				
◆	Bore Hole			
⊕	Cone Penetration Test			
⊕	Bore Hole & Cone Test			
⊕	Water level established at time of field investigation Jan 1972			
NO.	ELEVATION	STATION	OFFSET	
1	838.1	2+12	100' ET	
2	838.0	2+44	58' ET	
3	839.6	3+12	100' ET	
4	838.8	3+66	58' ET	
5	837.1	2+77	58' ET	
6	836.7	3+30	100' ET	
7	836.5	3+30	58' ET	
8	839.1	4+52	100' ET	
9	838.6	2+24	58' ET	
10	837.3	2+47	100' ET	
11	836.8	3+31	58' ET	
12	836.5	3+44	100' ET	
13	837.5	2+95	100' ET	
14	836.5	3+12	58' ET	
15	836.4	3+97	100' ET	
16	836.1	4+14	58' ET	

**NOTE**  
The boundaries between soil strata have been established on y or Bore Hole Sections. Between Bore Hole the boundaries are assumed from geological evidence and may be subject to considerable error.

NO.	DESCRIPTION
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	

MINISTRY OF TRANSPORTATION & COMMUNICATIONS  
DESIGN SERVICES BRANCH - FOUNDATIONS OFFICE

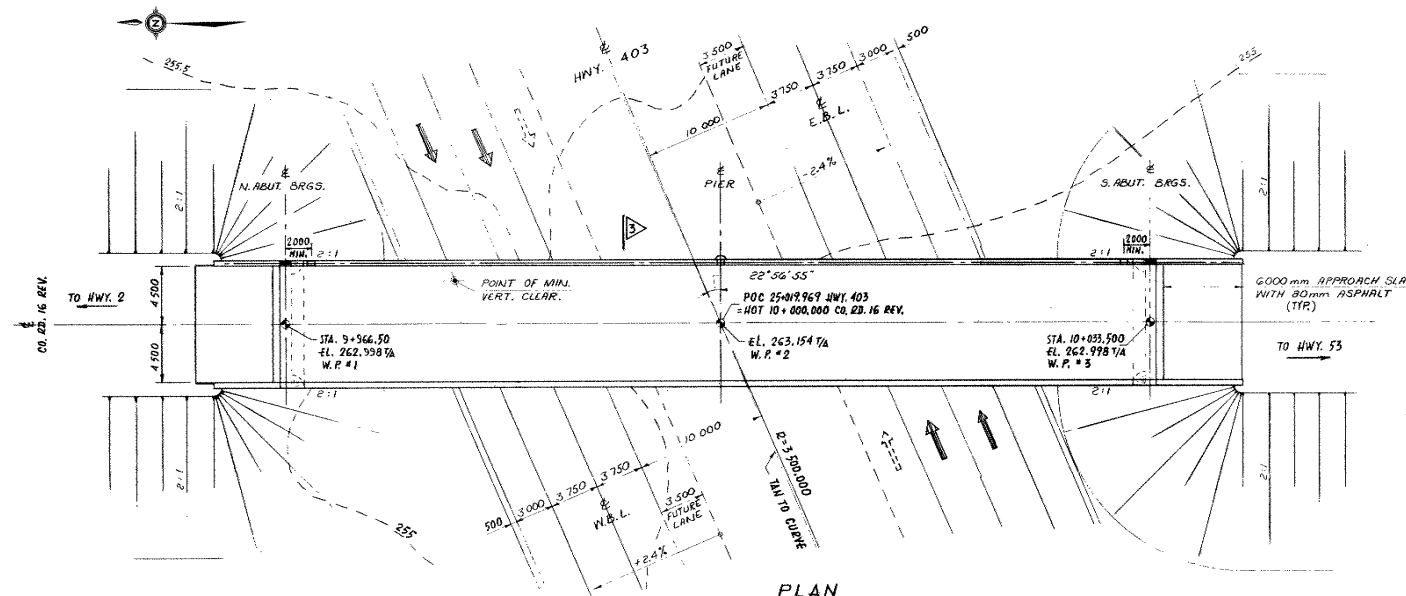
**COUNTY ROAD 16**  
(BISHOPSGATE ROAD)

HIGHWAY NO. Prop. 403 LINE 'E' DIST. NO. 4  
CO. BRANT  
TWP. BRANTFORD OF CON. II

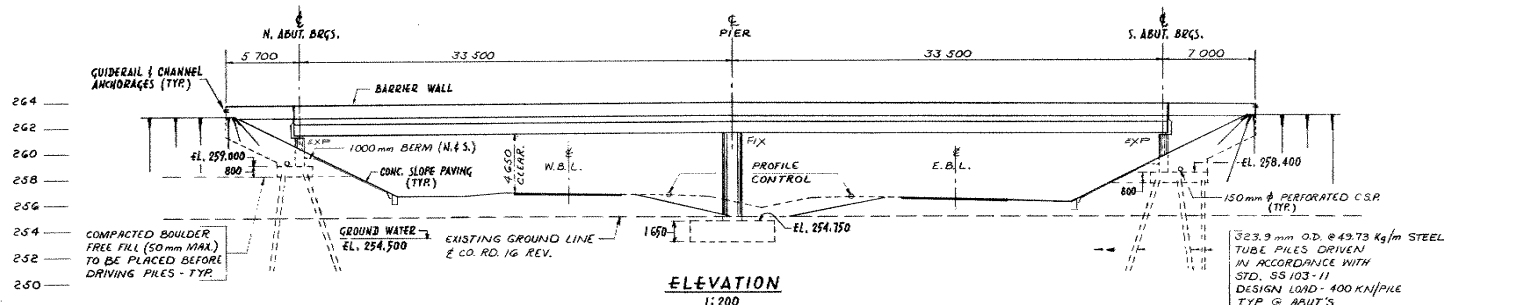
**BORE HOLE LOCATIONS & SOIL STRATA**

DRAWN BY: [Signature] CHECKED BY: [Signature] DATE: April 13, 1972  
APP. NO. 151-80-00 FOR NO. 71-11108A  
SHEET NO. 1 OF 1  
APPROVED BY: [Signature] DATE: [ ]

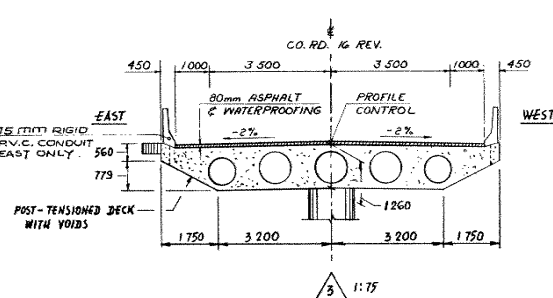
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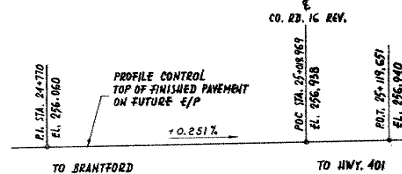
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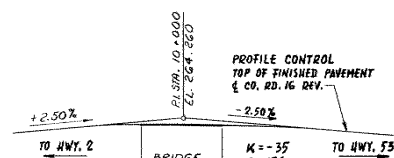
ELEVATION  
1:200



1:75



PROFILE HWY. 403  
N.T.S.



PROFILE CO. RD. 16 REV.  
N.T.S.

## METRIC

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

### NOTES:

- W.P. DENOTES WORKING POINT
- T/A DENOTES TOP OF ASPHALT WEARING SURFACE

DIST. NO 4 HWY. 403  
CONT No 81-43  
WP No 161-60-01

COUNTY RD. 16 U'PASS  
3.9 Km WEST OF HWY. 24A  
GENERAL ARRANGEMENT



SHEET  
155

### NOTES:

#### CLASS OF CONCRETE

DECK & PIER COLUMN 35 MPa  
BARRIER WALLS 30 MPa  
REINFORCING STEEL 20 MPa

#### REINFORCING STEEL

GRADE 400  
BAR MARK WITH SUFFIX 'C' DENOTES COATED BAR.

CLEAR COVER TO REINFORCING STEEL mm  
FOOTINGS, ABUTMENTS & PIER COLUMN 75  
DECK - TOP 50  
DECK - BOTTOM 40  
OR AS NOTED ON DRAWINGS

#### CONSTRUCTION NOTES

THE CONTRACTOR IS RESPONSIBLE FOR FINISHING THE BEARING SEATS DEAD LEVEL TO THE SPECIFIED ELEVATIONS WITH A TOLERANCE OF  $\pm 3$  mm.  
NO CONCRETE SHALL BE PLACED ABOVE THE ABUTMENT BEARING SEATS UNTIL CONCRETE IN THE DECK HAS BEEN PLACED, STRESSED & GROUTED.  
TO ACHIEVE THE MINIMUM CLEAR COVER OF 50 mm SPECIFIED AT TOP OF DECK, THE TOP LAYER OF REINFORCEMENT SHALL BE PLACED PRIOR TO CONCRETING, WITH A CLEAR COVER OF  $65 \pm 15$  mm TOLERANCE.

#### CONCRETE QUANTITIES

CONCRETE QUANTITIES ARE LISTED BELOW FOR THE APPROPRIATE CONCRETE LUMP SUM TENDER ITEMS

CONCRETE IN PIER, ABUTMENT & WINGWALLS 10 m<sup>3</sup>  
35 MPa 107 m<sup>3</sup>  
PRESTRESSED CONCRETE BRIDGE DECK 589 m<sup>3</sup>  
CONCRETE IN BARRIER WALLS 40 m<sup>3</sup>  
CONCRETE IN APPROACH SLABS 28 m<sup>3</sup>  
CONCRETE IN SLOPE PAVING 23 m<sup>3</sup>

#### LIST OF DRAWINGS

- 1-155-1 GENERAL ARRANGEMENT
- 2 BOREHOLE LOCATION & SOIL STRATA
- 3 FOOTING LAYOUT & REINFORCING
- 4 NORTH ABUTMENT
- 5 SOUTH ABUTMENT
- 6 PIER & PIER FOOTING
- 7 DECK DETAILS & ABUT. BEARINGS
- 8 LONGITUDINAL CABLE DETAILS
- 9 TRANSVERSE CABLE DETAILS I
- 10 TRANSVERSE CABLE DETAILS II
- 11 DECK REINFORCING I
- 12 DECK REINFORCING II
- 13 BARRIER WALL
- 14 6000 mm APPROACH SLAB
- 15 DETAILS OF CONC. SLOPE PAVING
- 16 AS CONSTRUCTED ELEV. & DIM.
- 17 BRIDGE DATE & SITE NUMBER DATA
- 18 BRIDGE ELECTRICAL DETAILS - TYPE IV
- 19 PILE DRIVING - STREAM & DIESEL HAMMERS
- 20 STANDARD DETAILS I
- 21 STANDARD DETAILS II
- 22 STANDARD DETAILS III
- 23 STANDARD DETAILS IV



DRAWING NOT TO BE SCALED  
100 mm ON ORIGINAL DRAWING

DATE	BY	CHECK	DESCRIPTION	DATE
2020-04-04	XXX	XXX	LOADING	2020-04-04
2020-04-04	XXX	XXX	SITE	2020-04-04



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

**SHEET**  
157

COUNTY RD. 16 U'PASS  
3.9 km. WEST OF HWY. 24A  
FOOTING LAYOUT & REINFORCING



REVISIONS				
	DATE	BY	DESCRIPTION	
	DESIGN K.Z.S.	CHECK <i>M.</i>	LOADING 45 20-44	DATE 80/S
	DRAWING P.K.	CHECK KA	SITE No 1-155	DWG 3



LOCATION	ROW	Nº	LENGTH	BATTER
NORTH ABUT.	FRONT	12	8 000	1:3
	MIDDLE	8	7 750	1:8
	BACK	2	7 750	VE2T.
SOUTH ABUT.	FRONT	12	7 500	1:3
	MIDDLE	8	7 000	1:8
	BACK	2	7 000	VE2T.

- ALL PILES ARE STEEL TUBE PILES (323.9 mm O.D., LINEAR DENSITY 49.73 kg/m),
- DESIGN LOAD IS 0.4 MN PER PILE,
- PILE SPACING TO BE MEASURED AT UNDERSIDE OF FOOTING,
- PILE LENGTH SHOWN ON THE DRAWING IS THE THEORETICAL LENGTH BELOW CUT-OFF.

CONCRETE QUANTITIES  
CONCRETE IN TUBE PILES — 7.70 m<sup>3</sup>

DRAWING NOT TO BE SCALED  
100 mm ON ORIGINAL DRAWING

S, TE 1-88-155-A-3



## **APPENDIX B**

### Site Photographs





**Photograph 1:** Looking at the south abutment of the Brant Road 16 Underpass Structure. No damages were observed on the front slope concrete panels. Minor surficial cracks were observed on the abutment walls. Weep holes were observed in the abutment wall. The adjacent slopes and the toe of the front slope were vegetated. Erosion of the slopes was not observed (August 28, 2015).



**Photograph 2:** Looking at the north abutment of the Brant Road 16 Underpass Structure. Minor damages were observed on the front slope concrete panels. Minor surficial cracks were observed on the abutment walls. Weep holes were observed in the abutment wall. The adjacent slopes and the toe of the front slope were vegetated. Erosion of the slopes was not observed (August 28, 2015).





**Photograph 3:** Minor cracks observed on the concrete panels of the north abutment of the Brant Road 16 Underpass Structure (August 28, 2015).



**Photograph 4:** Looking north at the centreline pier of the Brant Road 16 Underpass Structure. Minor surficial cracks were observed on the pier (August 28, 2015).



**Photograph 5:** Looking at the east wingwall and the adjacent slope of the south abutment of the Brant Road 16 Underpass Structure. Minor surficial cracks were observed on the wingwall. The slope is vegetated and effect of erosion on the slope face was not observed (August 28, 2015).





**Photograph 6:** Looking at the west wingwall and the adjacent slope of the south abutment of the Brant Road 16 Underpass Structure. Minor surficial cracks were observed on the wingwall. The slope is vegetated and effect of erosion on the slope face was not observed (August 28, 2015).



**Photograph 7:** Looking at the west wingwall and the adjacent slope of the north abutment of the Brant Road 16 Underpass Structure. Minor surficial cracks were observed on the wingwall. The slope is vegetated and effect of erosion on the slope face was not observed (August 28, 2015).



**Photograph 8:** Looking at the east wingwall and the adjacent slope of the north abutment of the Brant Road 16 Underpass Structure. Minor surficial cracks were observed on the wingwall. The slope is vegetated and effect of erosion on the slope face was not observed (August 28, 2015).