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DIST. 1 REGION SOUTH WESTERN

W.P. No. \_\_\_\_\_

CONT. No. \_\_\_\_\_

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

STR. SITE No. 14-209

HWY. No. \_\_\_\_\_

LOCATION TWP. 10.  $\frac{1}{2}$  BLACK CREEK,

LAMBTON CO., ENNISKILLEN TWP.,

CON. 2  $\frac{1}{2}$  3, LOT 6

=====

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

REMARKS: DOCUMENTS TO BE UNFOLDED

BEFORE MICROFILMED

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# DOMINION SOIL INVESTIGATION LIMITED

CONSULTING SOIL & FOUNDATION ENGINEERS

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MONTEITH INGRAM ENGINEERING LTD.  
CONSULTING ENGINEERS  
PETROLIA ONTARIO

40J16 - 56

GEOCREP No.

Report On  
SOIL INVESTIGATION  
for  
BLACK CREEK BRIDGE  
LOT 6 CONCESSION 2/3  
TOWNSHIP OF ENNISKILLEN

4-289

by

Dominion Soil Investigation Limited  
1220 Trafalgar Street  
London Ontario

Ref: 73-8-L5  
Oct. 22, 1973

Si

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I

INTRODUCTION

In accordance with instructions from Monteith-Ingram Engineering Limited, Consulting Engineers, a soil investigation has been carried out in the Township of Enniskillen, where it is proposed to replace an existing bridge with a new structure.

The existing 90-foot span bridge is located on the Concession 2/3 road in Lot 6 of the Township, where it crosses Black Creek, and it is understood that the new structure will be centred on the existing structure. The requirements of the project were discussed with Mr. G.W. Ingram P.Eng., who supplied the foregoing information.

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

## II

FIELD WORK

The field work, consisting of two boreholes accompanied by two dynamic cone penetration tests, was carried out on August 17, 1973, at the locations shown on Enclosure 2. The holes were advanced to the sampling depths by a self-propelled drilling machine, which was equipped with hollow-stem augers for soil sampling.

Standard penetration tests were performed at frequent intervals of depth, as detailed in Appendix 'A', and the results are recorded on the borehole logs as 'N' values. The split-spoon samples were stored in air-tight containers and transferred to our London laboratory for testing and storage.

Insitu vane shear tests were performed in the cohesive subsoil to determine the undrained shear strength. The procedure followed in this test is outlined in Appendix 'B'.

The dynamic cone penetration tests were performed adjacent to the borehole locations to obtain an indication of soil density and strata changes with depth. The energy used to drive the cone was the same as was used for the standard penetration tests.

The field work was supervised by a soils engineer, who also determined the pertinent ground surface elevations. These were referred to a nail and washer in the south root of a tree, and the benchmark was established by the client as having a Geodetic El. 612.31 feet.

### III SUBSURFACE CONDITIONS

Detailed descriptions of the strata, which were encountered in each borehole, are given on the borehole logs comprising Enclosures 3 and 4, and a general picture of the soil stratigraphy is presented in the form of a Subsurface Profile on Enclosure 2. The following notes are intended only to amplify this data.

Both boreholes encountered surface layers of silty clay and clayey silt fill, which are associated with the construction of the approaches to the existing bridge. The fill extends to depths of 12 and 9 feet in boreholes 1 and 2 respectively.

Underlying the fill the boreholes encountered a silty clay stratum which contains traces of roots and fragments of partially decomposed wood. The consistency of this material is described as 'firm to 'stiff'

based on 'N' values of 6 and 11 blows per foot. Two moisture content tests indicated a natural moisture content for this stratum of 24% to 29%.

The predominant soil type is a glacial silty clay, and it was encountered at El. 601.8 and El. 609.0 in boreholes 1 and 2 respectively. The silty clay contains embedded sand and gravel, and this type of material is commonly referred to as 'Glacial Till'. Due to the clay content the till should be regarded as a plastic and cohesive material, and the consistency is described as 'stiff' to 'very stiff' based on laboratory undrained shear strengths ranging from 1000 to 2500 p.s.f., field vane shear strengths ranging from 2800 to 3280 p.s.f., and 'N' values ranging from 9 to 23 blows per foot. Atterberg Limit tests were performed on two samples of the silty clay till giving values of Liquid Limit of 28% and 39%, Plastic Limit of 19% and 23%, and Plasticity Index of 9% and 16%. These values indicated that the silty clay has a low to intermediate plasticity and compressibility. The natural moisture content of the silty clay ranges from 21% to 24%, which is close to the plastic limit of the soil and confirms the generally 'stiff' to 'very stiff' consistency obtained from visual and tactile examination.

Borehole 1 encountered a layer of sandy silt till at El. 595.3, and the surface of shale bedrock was encountered at El. 591.3. The sandy silt has a 'compact' relative density as indicated by an 'N' value of 22 blows per foot. The shale was cored to a depth of 5 feet and the 100% core recovery shows that the shale is in a sound and unweathered condition. Refusal was encountered at El. 591 in borehole 2, and this is assumed to be the inferred bedrock surface. It also indicates that the surface of the bedrock is relatively flat across the site. Compression tests were performed on three 1.6 inch diameter by 3.2 inch long core samples of the shale and these gave values of ultimate compressive stress ranging from 11.9 to 15.3 kips per square inch with an average of 13.6 k.s.f.

## IV

GROUNDWATER CONDITIONS

An equilibrium water level was observed at El. 609.5 in borehole 1 and insufficient time was available for the water level in borehole 2 to reach an equilibrium state. The water level in the adjacent creek was observed at El. 605.8.





## DISCUSSION AND RECOMMENDATIONS

The investigation has shown that the site is underlain by a considerable thickness of stiff to very stiff glacial silty clay, which is suitable for the support of spread footing foundations. Alternatively the surface of the bedrock was encountered at El. 591± and consideration may also be given to the use of relatively short end-bearing piles.

### Spread Footing Foundations

The creek bed was encountered at El. 604±, therefore the footing grade should be established at or below El. 600 to provide sufficient protection against heave due to frost action. This level lies within the 'stiff' to 'very stiff' silty clay till stratum, and on the basis of the borehole results a maximum allowable soil pressure of 4000 p.s.f. is appropriate for the design of footings. This soil pressure incorporates a factor of safety of 3 against shear failure of the underlying soil.

Based on the results of consolidation tests on silty clay samples from nearby sites, the coefficient of volume compressibility of the 'stiff' to 'very stiff' silty clay has been assumed to be 0.012 sq. ft. per ton, and the long term consolidation settlement which will occur below a 12-foot wide footing carrying a dead load of 3000 p.s.f. is calculated to be  $1\frac{1}{2}$  inches. Applying Skempton and Bjerrum's lateral strain correction, and using a value of 0.4 for pore pressure coefficient 'A', the value of the actual settlement is estimated to be 0.75 inch. In view of the uniformity of consistency, moisture content and thickness of the silty clay below the footing grade level, no appreciable differential settlement is anticipated.

The adhesion between footings and the underlying silty clay may be taken as 1000 p.s.f., and the factor of safety against horizontal sliding of the abutments must be at least 1.5.

In the case of a spread footing design it is recommended that the subgrade be covered with a lean concrete mat to prevent disturbance as soon as it has been inspected and approved. Disturbed material at the grade level should be removed and replaced with lean concrete.

Pile Foundations

Due to the proximity of the shale bedrock at a depth of about 14 feet below the creek bed level, end-bearing piles should be considered. Any driven type of pile would be satisfactory, the most common types being concrete filled steel tubes and H-piles. The following working loads may be used for the design of piles driven to refusal in the bedrock.

<u>Pile Type</u>	<u>Working Load</u> <u>Tons</u>
8 BP 36	63
10 BP 42	74
10 BP 57	100
12 BP 53	93
10.75 inch tube (4000 p.s.i. concrete)	60
12.75 inch tube (4000 p.s.i. concrete)	100

The loadings for the H-piles are based on a stress of 12 kips per square inch over the area of the pile, which is less than the average compressive strength of the shale bedrock.

The general rule for refusal of a pile is that 5 blows of an adequate hammer produce a total penetration of  $\frac{1}{4}$  inch. Driving should then cease providing that the pile has not hit an obstruction, and has been driven to a depth at which refusal is expected. When piles are driven to refusal in rock, pile loading tests are not considered necessary.

Yours very truly,

DOMINION SOIL INVESTIGATION LTD.



CJWA:eg

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

## APPENDIX 'A'

### THE STANDARD PENETRATION TEST.

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

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

For Sands:-

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

## APPENDIX 'B'

### INSITU VANE SHEAR TEST











In soft to stiff clays, and particularly sensitive clay soils such as frequently occur in alluvial deposits, it is difficult to obtain reasonable undisturbed samples for the determination of the undrained shear strength. In order to overcome this difficulty, the vane test was developed as an in-situ method of measuring the shear strength.

The apparatus consists of a 4-inch long by 2-inch wide rectangular 4-bladed rotating vane attached to a thin rod, which is pushed into the undisturbed soil below the bottom of the borehole to the depth at which the test is to be made.

A torque is then applied to the vane and the maximum torque when failure occurs is recorded. The vane is then rotated 10 times to remould the soil and after one minute the torque test is repeated. The shear strength of the soil can then be calculated from the torque and the dimensions of the vane, and the sensitivity of the material estimated from the ratio of the original torque to the final torque after remoulding.

# LIST OF SYMBOLS, ABBREVIATIONS AND NOMENCLATURE.




## SOIL COMPONENTS AND GROUND WATER CONDITIONS.



									
COULDER	COBBLE	GRAVEL	SAND	SILT	CLAY	ORGANICS	BEDROCK	GROUND WATER LEVEL	DEPTH OF CAVE-IN
3"	> 8"	3"	4.75mm	0.075	0.002	>	NO SIZE LIMIT		
U.S. Standard Sieve Size:		No. 4	No. 10	No. 40	No. 200				

## SAMPLE TYPES.

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

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

OBSERVATIONS MADE WHILE CORING  
 Steady pressure  
 No pressure  
 Intermittent pressure

 Washwater returns  
 Washwater lost

## PENETRATION RESISTANCES.

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

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

### EXTRAPOLATED -N- VALUE

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

SYMBOL :



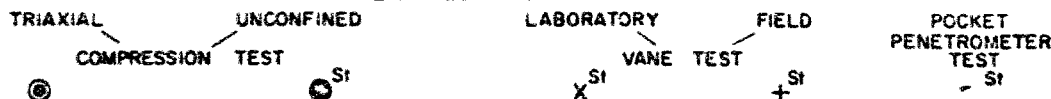
322

## SOIL PROPERTIES.

W % Water content	$\gamma$ Natural bulk density (unit weight)	k Coeff. of permeability
LL % Liquid limit	e Void ratio	$\tau$ Shear strength
PL % Plastic limit	RD Relative density	$\phi$ Angle of int. friction
PI % Plasticity index	$C_v$ Coeff. of consolidation	$C'$ Cohesion
LI Liquidity index	$m_v$ Coeff. of volume compressibility	$\phi'$ Angle of int. friction

## UNDRAINED SHEAR STRENGTH.

- DERIVED FROM -



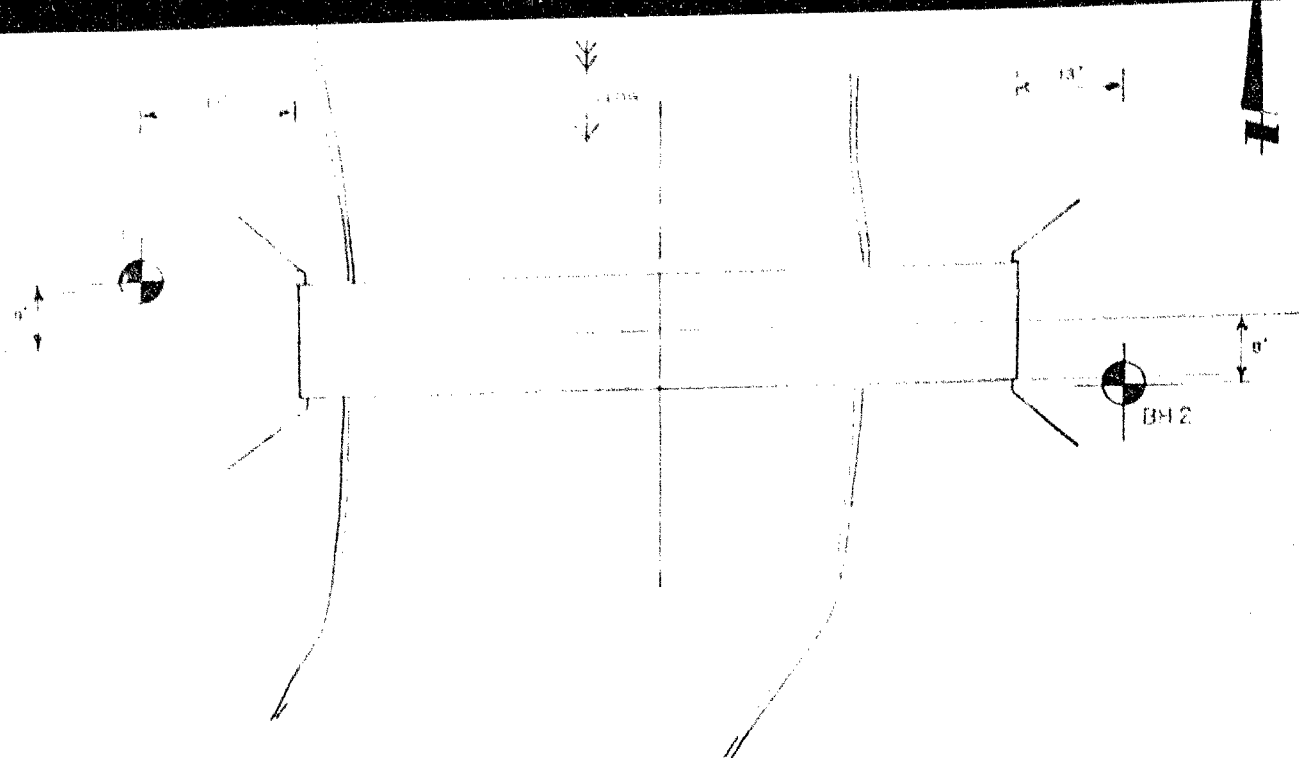
Strain at failure is represented by direction of stem

20%  
15% + 5%  
10%

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

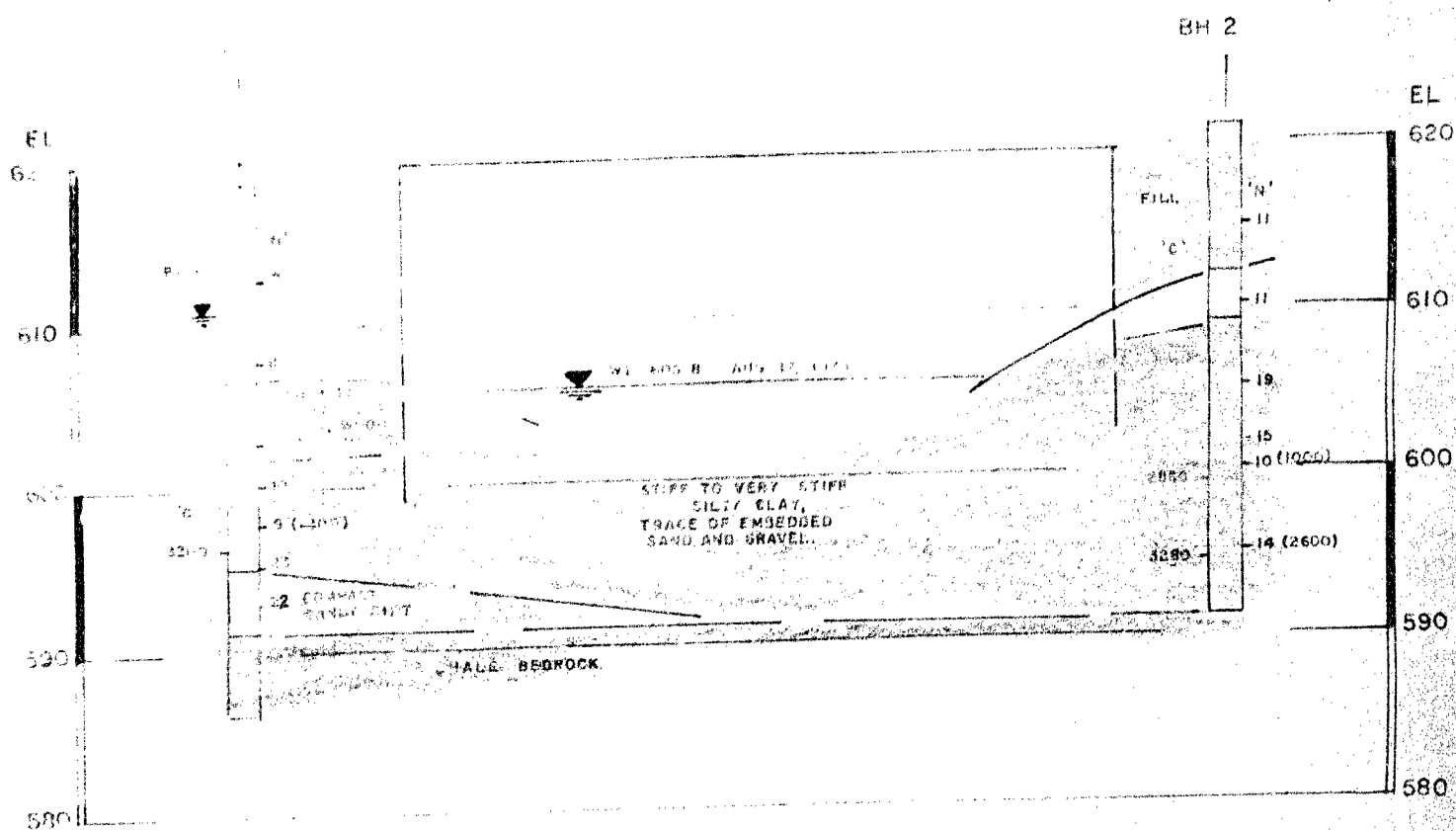
## SOIL DESCRIPTION.

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



LOCATION OF BOREHOLES

SCALE: 1" = 20'



SUBSURFACE PROFILE

SCALE HOR. 1" = 20'

VERT. 1" = 10'



## LOG OF BOREHOLE

Enclosure No. \_\_\_\_\_

Our Reference No. 73-8-15

CLIENT: Monteith Ingram Engineering Limited,  
PROJECT: Black Creek Burden  
LOCATION: Conc. 2/3, Lot 6, Pwr. of Evershaddon  
DATUM ELEVATION: Nail in tree foot, Pl. 612.31 feet

## DRILLING DATA

Method. Hollow-stem auger.  
Diameter. 15-cm  
Date. Aug. 17, 1973

[illegible]

# LOG OF BOREHOLE

Enclosure No. 4

Our Reference No. 73-M-1

## DRILLING DATA

Method: Hollow-stem auger.  
Diameter: 8-inch  
Date: Aug. 17, 1973.

CLIENT: Montreal Iron & Engineering Limited  
PROJECT: Black Creek Bridge  
LOCATION: Conc. 2/3, Lot 6, Twp. of Smithville  
DATUM ELEVATION: Nail in tree root, El. 612.11 feet

LOCATION: Cond. 275, Box 47, Nipaw, Sask.		DATE: AUG. 17, 1977.																
DATUM ELEVATION: Nail in tree root, El. 612.11 feet.																		
SUBSURFACE PROFILE		SAMPLES		PENETRATION RESISTANCE Blows/Ft.					WATER CONTENT %			REMARKS						
ELEVATION Ft.	DEPTH Ft.	DESCRIPTION	SYMBOL	GROUND WATER	NUMBER	TYPE	'N' Blows/Ft.	UNDRAINED SHEAR STRENGTH 100 p.s.f.					PLASTIC LIMIT W <sub>p</sub>	NATURAL W	LIQUID LIMIT W <sub>L</sub>			
								+ FIELD VANE TEST      • COMPRESSION TEST										
								20	40	60	80	100	10	20	30	40	50	
621.0	0.0																	
620		Brown silty clay.																
615		FILL.			1	SS	11											
	9.0																	
610		Stiff grey-brown silty clay, pieces of wood.			2	SS	11											
	12.0																	
615		Stiff to very stiff grey-brown silty clay,			3	SS	19											
		traces of embedded sand and gravel.			4	SS	15											
600		seams of silt			5	SS	10											
					6	SS	14											
595																		
590	30.0	End of Borehole																

Refusal at El. 591 Inferred Bedrock.

### Unified Soil Classification Plasticity Chart

**ML Inorganic silts and very fine sands, silty or clayey fine sands, or clayey silts with slight plasticity.**

**CL** inorganic clays of low plasticity, gravelly clays, sandy clays, silty clays, lean clays.

**OL** Organic silts and organic silty clays of low plasticity.

M1 Inorganic silts, clayey fine sands or clayey silts with medium plasticity.

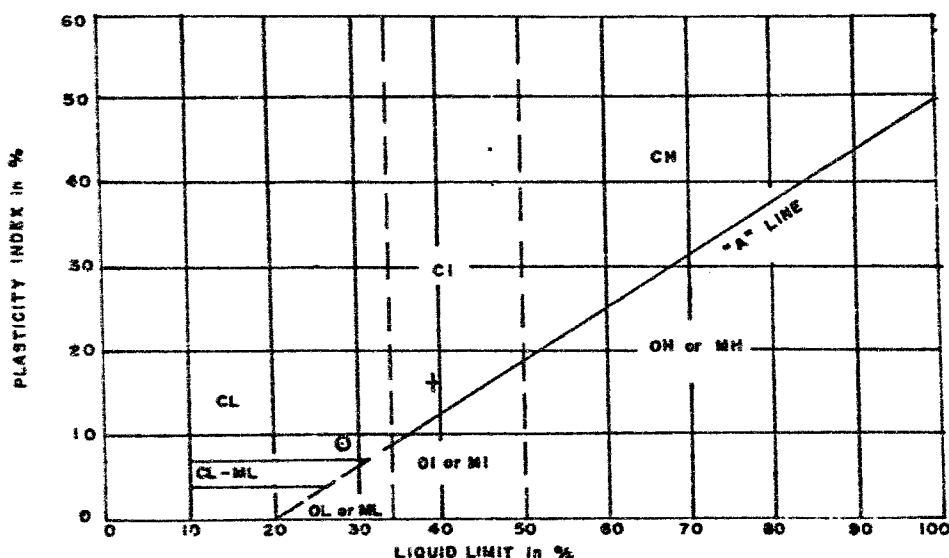
**C1** Inorganic clays with medium plasticity, sandy clays, silty clays.

**01 Organic silts and organic silty clays of medium plasticity.**

MM Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.

**CH Inorganic clays of high plasticity, fat clays.**

**OH Organic silts and organic clays of high plasticity.**



PROJECT:	Black Creek Bridge	
LOCATION:	Cons 2/3, Township of Enniskillen	
BOREHOLE NO.:	1	2
SAMPLE NO.:	4	3
DEPTH OF SAMPLE:	18'	16'
ELEVATION OF SAMPLE:	601'	610'
LIQUID LIMIT: %	27.8	38.8
PLASTIC LIMIT: %	18.8	23.0
PLASTICITY INDEX: %	9.0	15.8
MOISTURE CONTENT: %	21.9	23.0
LIQUIDITY INDEX:	0.34	0.0
LEGEND:	o	†

**DOMINION SOIL INVESTIGATION LIMITED****CONSULTING SOIL & FOUNDATION ENGINEERS**

104 CROCKFORD BLVD., SCARBOROUGH, ONT. (416) 751-6565 TELEX 02-21210 CABLES: DOMSOIL

P.O. Box 4033, Station 'C',  
London, Ontario.

Report On: Shale Bedrock.

Client:

Type: Bx core.

Ref. No: 73-8-L5

File No:

Clients No:

Date: 16 October, 1973.

Specification:

Source:

Date Received in Lab:

Sampled by:

On (date)

COMPRESSION:

Lab. No.		1	2	3	4	5
Mean area	sq ins	2.06	2.06	2.06		
Maximum load	lb	28,200	24,500	31,500		
Compressive strength	lb/sq inch	13,690	11,890	15,290		

AVERAGE COMPRESSIVE STRENGTH 13,620 lb/sq inch

DOMINION SOIL INVESTIGATION LIMITED,



P.H. Davies, P. Eng.