

B.M. ROSS & ASSOCIATES LIMITED  
CONSULTING ENGINEERS  
62 NORTH STREET  
GODERICH ONTARIO

Geocres No:

40P14-17

Report on  
SOIL INVESTIGATION

for

BRIDGE BR-376

LOT 20, CONCESSION 7 'B' LINE  
TOWNSHIP OF TURNBERRY

Geocres 40P14-017

WO 2006-11011

by

Dominion Soil Investigation Limited  
164 Newbold Court  
London Ontario  
N6E 1Z7

Ref: 77-6-L5

STRUCTURE SITE No. 12-67

July 8, 1977

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## I INTRODUCTION

In accordance with a letter of authorization from B.M. Ross and Associates Ltd., Consulting Engineers, dated June 10, 1977, a soil investigation has been carried out in the Township of Turnberry, where it is proposed to replace an existing bridge with a new structure.

The existing two span bridge is located on the 'B' line opposite Lot 20 Concession 7 of the Township, where the road crosses the Maitland River. It is understood that the proposed structure is a three span bridge with a centre span of 70 feet and a total span of 150 to 160 feet, and that it will be centred on the existing bridge. The requirements of the project were discussed with Mr. K.G. Dunn, P. Eng. who supplied the foregoing information.

## II FIELD WORK

The field work, consisting of 4 sampled boreholes, was carried out during the period June 16 to 22, at the locations shown on the Enclosure 2. The holes were advanced to the sampling depths by a self-propelled CME 750 power auger machine, which was equipped with hollow-stem augers and standard soil sampling equipment.

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, which were transferred to our London laboratory for classification, testing and storage.

The field work was supervised by a soils technician, who also related the ground surface elevations to a Geodetic benchmark which was provided by the client. The benchmark was taken as a nail in a hydro and telephone pole, at Station 9+18, and it was given a value El. 1039.70 feet.

### III SUBSURFACE CONDITIONS

Detailed descriptions of the strata, which were encountered in each borehole, are given on the borehole logs comprising Enclosures 3, 4, 5, 6, and 7. The following notes are intended only to amplify this data.

Boreholes 1, 4 and 4A encountered fill material which is associated with the construction of the approaches to the existing bridge. The fill generally consists of sand and gravel and clayey silt in which traces of topsoil were observed. At borehole 1 and 4 locations a layer of wood was encountered below the fill, and borehole 4 encountered refusal at a depth of 15.3 feet, which is attributed to a large boulder or possibly the existing concrete foundation. Borehole 1 penetrated the wood layer between depths of 12 and 17 feet,

and thereafter the subsoil consists of a 'very dense' sand and gravel followed by 'very dense' sandy silt till. Borehold 4A was relocated to miss the obstruction encountered at Borehole 4 location, and it also encountered native subsoil below a peaty topsoil layer at a depth of 14 feet. The native subsoil consists of successive layers of 'dense' sand and gravel and silty sand, overlying 'very dense' sandy silt till in which the borehole was terminated.

Boreholes 2 and 3 were located in the existing river bed, and penetrated a surface layer of sand and gravel in which cobbles and boulders were encountered. The sand and gravel layer extends to depths of  $4\frac{1}{2}$  and  $2\frac{1}{2}$  feet, and is followed by a layer of 'dense' to 'very dense' sandy clayey silt till. - This stratum extends to depths of  $9\frac{1}{2}$  and 12 feet, and at both borehole locations it is followed by the 'very dense' sandy silt till stratum which was encountered in boreholes 1 and 4A.

Grading analysis of representative samples of the sandy clayey silt till and sand and gravel strata are shown as grain size distribution curves on Enclosure 8.

#### IV GROUNDWATER CONDITIONS

Due to the necessity of using washwater to advance the boreholes, it was not possible to observe the groundwater at borehole 1 and 4



locations, however the water level in the adjacent river was observed at elevation 1022.6, and the river level may be assumed to be the prevailing water table during the construction period.

## V DISCUSSION AND RECOMMENDATIONS

The investigation has shown that the native soil profile below the fill at the present abutment locations, and below the river bed level near the proposed pier locations, consists of very dense sand and gravel in which cobbles and boulders were encountered, overlying very dense sandysilt or sandy clayey silt till. The average river bed level extends down to elevation 1022±, however part of the river bed has been scoured down to elevation 1018.4.

In the design of normal spread footing foundations it is customary for the footing depth to be located at least 4 feet below the river bed level for protection against frost action, and also below the predicted scour level to prevent undermining of the footings. The existing very dense sand and gravel and silt till materials are suitable for the support of spread footing foundations, and on the basis of the borehole results a maximum allowable soil pressure of 5 tons per square foot is appropriate for the design of footings at or below elevations 1017. This soil pressure incorporates a factor of safety of at least three against shear failure of the underlying soil, and



total settlement of footings is estimated to be 0.5 inch or less.

A problem in the construction of the footings will be control of the groundwater, and it is considered that the flow through the upper layer of sand and gravel will be too great to be controlled by normal pumping procedures. This being the case, the excavation should be carried out under water, and if the base of the excavation is put down into the sandy silt till material, the greater part of the infiltration will occur through the sand and gravel in the sides of the excavation. This flow can be curtailed by the use of close fitting tongue and groove formwork, and back-filling around the formwork using impervious type of fill. It is recommended that a layer of tremie concrete be poured on the base of the excavation to provide a clean working surface and prevent disturbance of the subgrade once it has been approved.

In assessing the resistance of foundations to the lateral forces, we recommend that a coefficient of friction of 0.45 be used, and the design should incorporate a factor of safety against sliding of not less than 1.5.



The lateral earth pressures acting on the rear of abutment and wing walls can be calculated using a triangular stress distribution which is given by:

$$P = W \times H \times K$$

where P = pressure at any depth

W = Unit weight of granular backfill, 125 p.c.f.

H = Height of backfill, feet.

K = Coefficient of earth pressure, 0.4

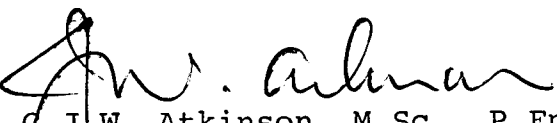
Surcharge and live loads will be additional to the earth pressure calculated using this formula.

The granular backfill should be provided with adequate drainage to prevent the build-up of hydrostatic pressures behind the abutments. Excavations above the water table should be stable with side slopes of 1:1 during the construction period, and below the water table the side slopes should be flattened to 3:1.



Yours very truly,

DOMINION SOIL INVESTIGATION LTD.

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

CJWA:pw

## 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'

STATEMENT OF LIMITATION

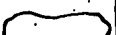





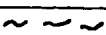

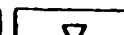

The conclusions and recommendations in this report are based on information determined at the borehole locations and on geological data of a general nature which may be available for the area investigated. Soil and ground-water conditions between and beyond the boreholes may differ from those encountered at the borehole locations and conditions may become apparent during construction which could not be detected or anticipated at the time of the soil investigation.

We recommend that we be retained to ensure that all necessary stripping, subgrade preparation and compaction requirements are met, and to confirm that the soil conditions do not deviate materially from those encountered in the boreholes. In cases where this recommendation is not followed, the company's responsibility is limited to interpreting accurately the information encountered at the boreholes.

This report is applicable only to the project described in the introduction, constructed substantially in accordance with details of alignment and elevation quoted in the text.

# LIST OF SYMBOLS, ABBREVIATIONS AND NOMENCLATURE.

## SOIL COMPONENTS AND GROUND WATER CONDITIONS.

												
BOULDER	COBBLE	GRAVEL		SAND			SILT	CLAY	ORGANICS	BEDROCK	GROUND WATER LEVEL	DEPTH OF CAVE-IN
		COARSE	FINE	COARSE	MEDIUM	FINE						
3"	> 8"	3"	3/4"	4.76mm	2.0	0.42	0.074	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	OBSERVATIONS MADE WHILE CORING	Steady pressure	Washwater returns
" " pressure : p		No pressure	Washwater lost
" " topping : t		Intermittent pressure	

## PENETRATION RESISTANCES.

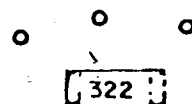
**DYNAMIC PENETRATION RESISTANCE :** to drive a 2", 60° cone attached to the end of the drilling rods into the ground, expressed in blows per foot.

**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:

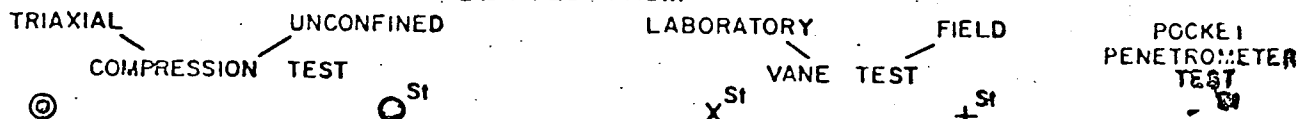


## SOIL PROPERTIES.

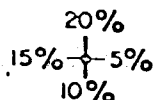
W % Water content	$\gamma$ Natural bulk density (unit weight)	k Coeff. of permeability
LL % Liquid limit	e Void ratio	C Shear strength
PL % Plastic limit	RD Relative density	$\phi$ Angle of int. friction
PI % Plasticity index	Cv Coeff. of consolidation	C' Cohesion
LI Liquidity index	m <sub>v</sub> Coeff.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

## UNDRAINED SHEAR STRENGTH.

- DERIVED FROM -



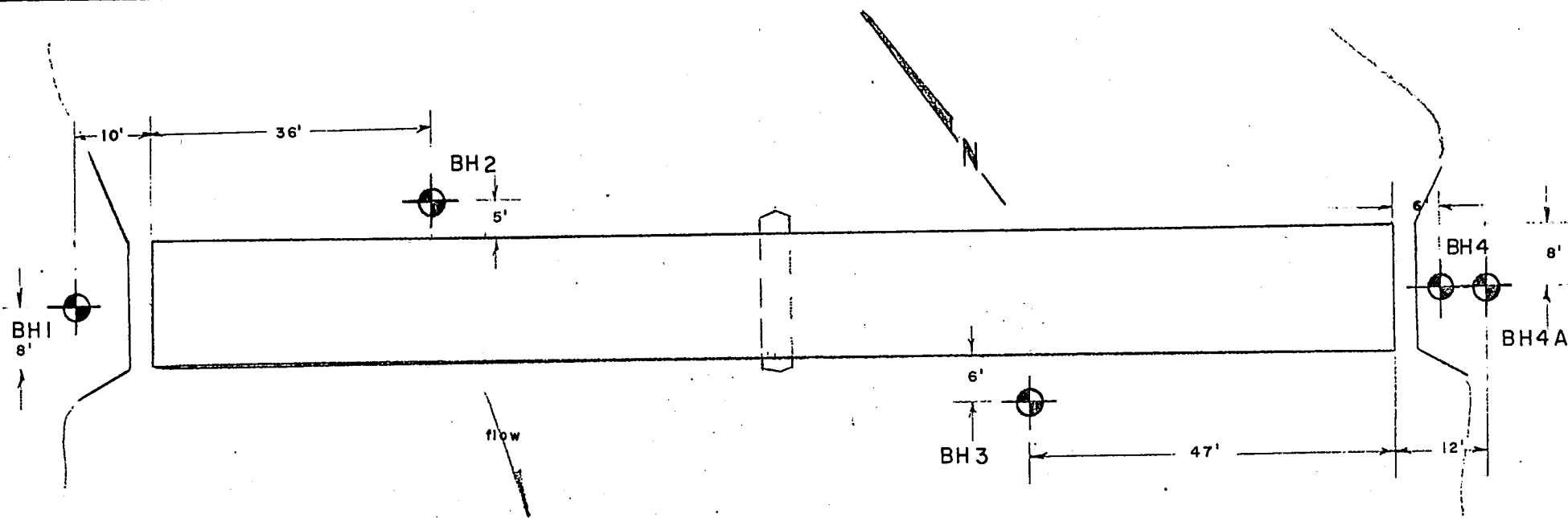
Strain at failure is represented by direction of stem



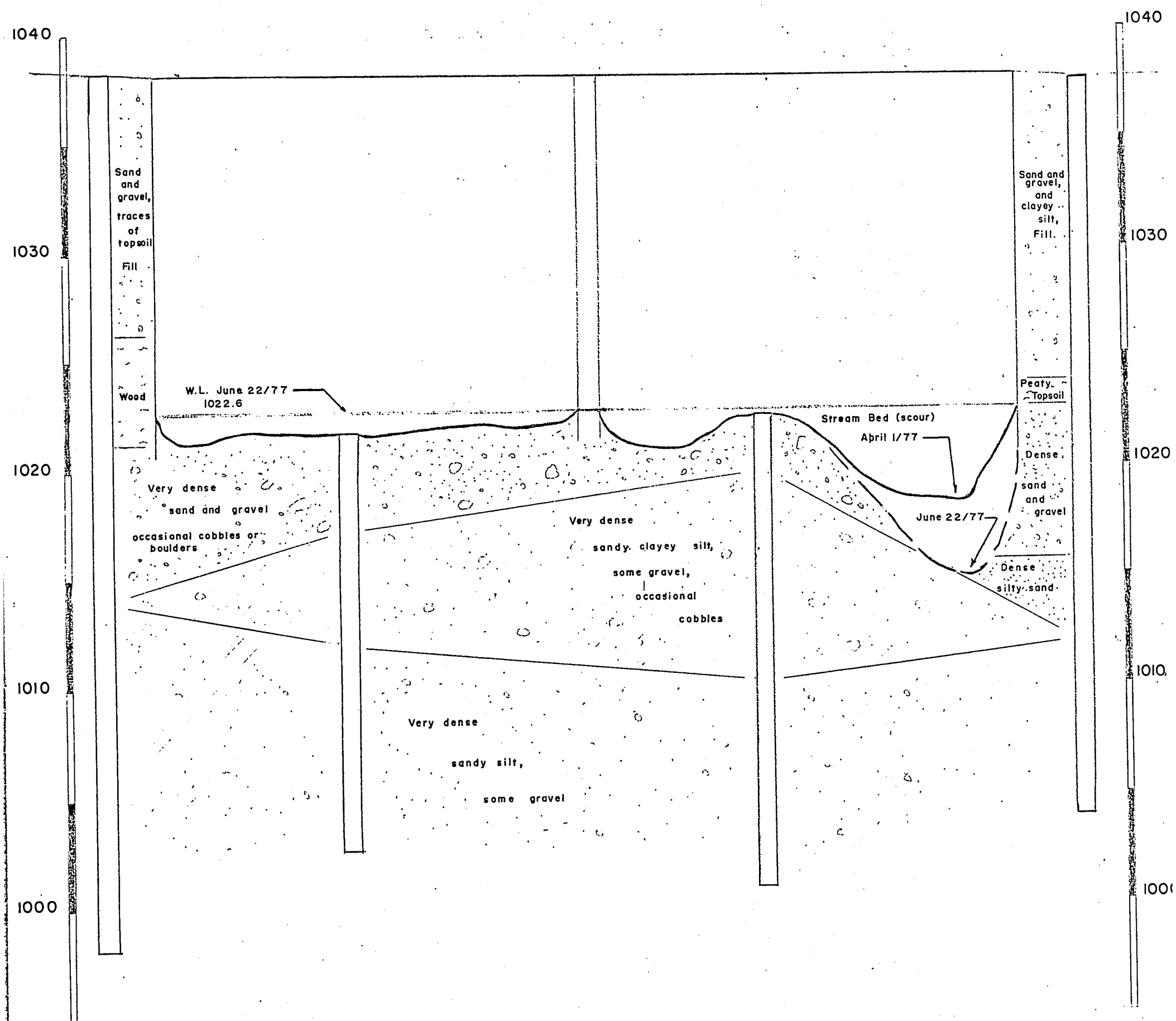
$$St = \text{sensitivity} = \frac{\text{shear strength in undisturbed state}}{\text{shear strength in remoulded state}}$$

## 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



SITE PLAN  
Scale: vert 1"=5'  
horiz 1"=20'



CLIENT: B. M. Ross and Associates Ltd.

DRILLING DATA

PROJECT: Proposed Bridge BR-376

Method: Auger

LOCATION: Township of Turnberry

Diameter: Hollow stem

DATUM ELEVATION: Nail in hydro pole, El. 1039.70 ft. Date: June 22, 1977

SUBSURFACE PROFILE			SAMPLES			PENETRATION RESISTANCE					Blows / ft.				PLASTIC LIMIT %	NATURAL WATER %	LIQUID LIMIT %		
ELEVATION Ft.	DEPTH Ft.	DESCRIPTION	SYMBOL	GROUND WATER	NUMBER	TYPE	'N'	Blows / Foot	20	40	60	80	100						
									Undrained Shear Strength + Field vane test					p.s.f. Compression test					
B2 0.0 Ground Surface																			
35		Sand and gravel, traces of topsoil Fill			1	SS	19												
30																			
25																			
22.0		Wood			2	SS	2												
20																			
17.0		Very dense sand and gravel occasional cobbles or boulders			3	SS	41												
15																			
12.0		Very dense sand and gravel occasional cobbles or boulders			4	SS	7 5/6"												
10																			
8.0		Very dense sandy silt, some gravel			5	SS	70/5"												
6.0																			
4.0		Very dense sandy silt, some gravel			6	SS	104												
2.0																			
0.0		Very dense sandy silt, some gravel			7	SS	7 5/6"												
		Very dense sandy silt, some gravel			8	SS	7 5/6"												
		Very dense sandy silt, some gravel			9	SS	90/9"												
		End of Borehole																	

MADE:

CHECKED:

# LOG OF BOREHOLE .2...

REF. NO: 77-6-L5

Encl. No: 4

CLIENT: B. M. Ross and Associates Ltd.

DRILLING DATA

PROJECT: Proposed Bridge BR-376

Method: Auger

LOCATION: Township of Turnberry

Diameter: Hollow stem

DATUM ELEVATION: Nail in hydro pole, El. 1039.70 ft. Date: June 22, 1977.

SUBSURFACE PROFILE				SAMPLES			PENETRATION RESISTANCE					Blows /ft.	PLASTIC LIMIT %	NATURAL WATER %	LIQUID LIMIT %	
ELEVATION Ft.	DEPTH Ft.	DESCRIPTION	SYMBOL	GROUND WATER	NUMBER	TYPE	'N'	Blows /Foot	20	40	60	80				100
									Undrained Shear Strength + Field vane test					p.s.f. Compression test		
102.7	0.0	Ground Surface														
20		Sand and gravel with boulders or cobbles			1	SS	72									
45		Dense to very dense grey sandy clayey silt, some gravel			2	SS	43									
15					3	SS	10/11'									
95					4	SS	10/8"									
10		Very dense grey sandy silt, some gravel			5	SS	10/10'									
05																
200					6	SS	75/4"									
00		End of Borehole														

MADE:

CHECKED:

□

## DRILLING DATA

Method : Auger

Diometer: Hollow stem

Date: June 22, 1977

MADE IN \_\_\_\_\_ CHECKED \_\_\_\_\_

CLIENT: B. M. Ross and Associates Ltd.

DRILLING DATA

PROJECT: Proposed Bridge BR-376

Method: Auger

LOCATION: Township of Turnberry

Diameter: Hollow stem

DATUM ELEVATION: Nail in hydro pole, El. 1039.70 ft. Date: June 22, 1977

SUBSURFACE PROFILE			SAMPLES			PENETRATION RESISTANCE					Blows / ft.				PLASTIC LIMIT %	NATURAL WATER %	LIQUID LIMIT %	
ELEVATION Ft.	DEPTH Ft.	DESCRIPTION	SYMBOL	GROUND WATER	NUMBER	TYPE	'N'	Blows / Foot	20	40	60	80	100					
									Undrained Shear Strength p.s.f.									
									+ Field vane test					Compression test				
Ground Surface																		
1037.60.0																		
35	2.5	Sand and gravel																
		Sandy silt, Fill			1	SS	14											
30																		
	12.0	Wood, sand and gravel			2	SS	27											
25																		
	15.3	Refusal, probably concrete			3	SS	60/3"											
20																		

CLIENT: B. M. Ross and Associates Ltd.

DRILLING DATA








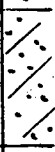


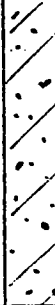


PROJECT: Proposed Bridge BR-376

Method: Auger

LOCATION: Township of Turnberry

Diameter: Hollow stem

DATUM ELEVATION: Nail in hydro pole, El. 1039.70 ft. Date: June 16, 1977

SUBSURFACE PROFILE			SAMPLES			PENETRATION RESISTANCE			Blows / ft.			PLASTIC LIMIT %	NATURAL WATER %	LIQUID LIMIT %
ELEVATION Ft.	DEPTH Ft.	DESCRIPTION	SYMBOL	GROUND WATER	NUMBER	TYPE	'N'	Blows / Foot	Undrained Shear Strength + Field vane test	ps.f.	Compression test			
37.6	00	Ground Surface												
35		Sand and gravel, and clayey silt, Fill												
30														
25					1	SS	18							
140		Peaty Topsoil												
150					2	SS	68							
20		Dense sand and gravel												
					3	SS	31							
220														
15		Dense silty sand			4	SS	46							
255					5	SS	100	9"						
10		Very dense grey sandy silt, some gravel												
					6	SS	65							
05					7	SS	100	11"						
335		End of Borehole												

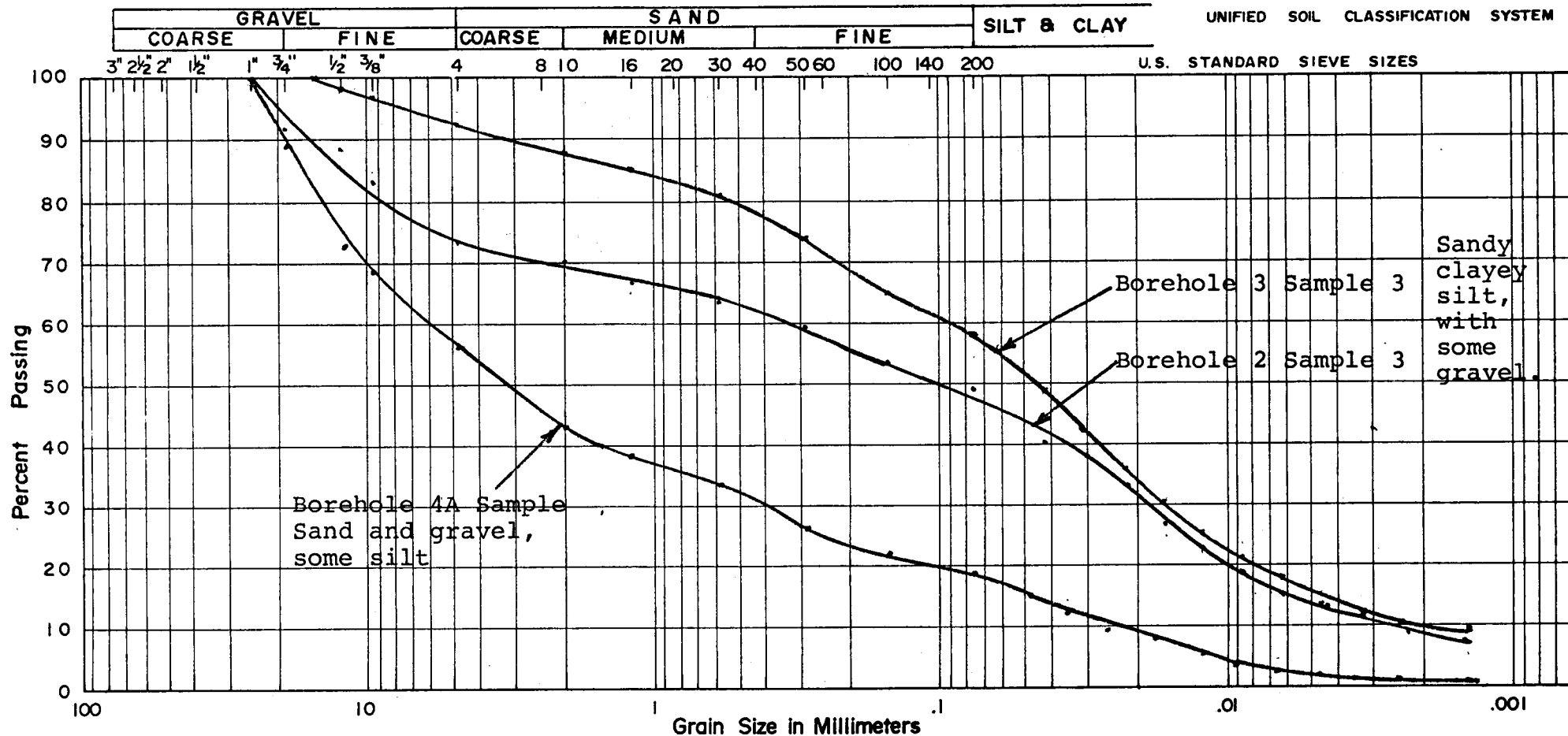
MADE:

CHECKED:

# DOMINION SOIL INVESTIGATION LIMITED

## GRAIN SIZE DISTRIBUTION

77-6-L5  
OUR REFERENCE N<sup>o</sup> .....



PROJECT: Bridge BR-376  
 LOCATION: Township of Turnberry  
 BOREHOLE N<sup>o</sup>: 2      3      4A  
 SAMPLE N<sup>o</sup>: 3      3      3  
 DEPTH: 8'      8'      21'  
 ELEVATION: 1014' 1014' 1017'

COEFFICIENT OF UNIFORMITY :  
 COEFFICIENT OF CURVATURE :

Classification of Sample and Group Symbol:

PLASTIC PROPERTIES

LIQUID LIMIT	% =
PLASTIC LIMIT	% =
PLASTICITY INDEX	% =
MOISTURE CONTENT	% =