

G.I.-30 SEPT. 1975

GEOCRES No. 40P15-26DIST. 3 REGION southwestern

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

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

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

STR. SITE No. 35-119

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

LOCATION LOT 26 § 27 CON. 6ARTHUR TWP.

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

REMARKS: DOCUMENTS TO BE UNFOLDED BEFOREMICROFILM

40 P15 map. BA 1776  
DOMINION SOIL INVESTIGATION LIMITED

77 CROCKFORD BOULEVARD SCARBOROUGH, ONTARIO TELEPHONE 421-2567

RANCH  
3 QUEENS AVENUE  
LONDON, ONTARIO  
TELEPHONE GE. 3-3851



FOUNDATION ENGINEERS

P.O. BOX 933  
SAULT STE. MARIE  
ONTARIO  
TELEPHONE AL. 4-2615

February 26th, 1964.



Mr. V. R. Astrop,  
Consulting Engineer,  
4 Hughson Street South,  
HAMILTON, Ontario.

R E P O R T

RE: A R N O L D   B R I D G E  
Our Reference No. 4-1-6

Dear Mr. Astrop:

The soil testing and subsequent engineering analysis was completed on the above project in accordance with your authorization of January 17th, 1964. This report presents our findings and recommendations.

FIELD WORK

The explorations were carried out between January 31st and February 5th, 1964 with a skid mounted washboring rig. Four borings were made as specified on your "site plan" provided to us and their locations were as close to the designated positions as practicable under the prevailing field conditions. The elevations of the boreholes were referred to a spike in a corner fence post about 600 ft. north of the bridge which was taken as elevation 100.0 ft.

Samples were taken at frequent intervals of depth with a 2 in. O.D. split spoon sampler driven into the substrata with a constant driving energy and by counting the blows to advance the sampler one foot, the standard penetration resistances were obtained. In addition, two dynamic cone penetration tests were performed in the vicinity of boreholes #1 and #2 giving a continuous record of the subsoil density.

Diamond drilling with an Axt core barrel was the only possible method of boring in the very dense cemented sandy silt.

#### LABORATORY WORK

After the field work was completed, some samples were further tested in the laboratory. The purpose of these tests was to determine the types and engineering properties of the materials encountered more accurately. The grain size distribution curve of a silt sample (B.F. 2, Sa. 8) is presented on a separate enclosure (#7) while the water contents, unit weights and Atterberg limits of the selected representative specimens were recorded on the appropriate geotechnical data sheets.

#### SUBSURFACE CONDITIONS

A 12 to 24 inches thick layer of granular road fill was encountered in all four boreholes comprising the uppermost portion of the road embankment which in turn consists of clayey sand and silt with some organic matter. It has a firm to stiff consistency and appears to be highly weathered.

FILL

The first natural stratum is a highly preconsolidated hard silty clay of glacial origin with the following average properties:

HARD  
SILTY  
CLAY

Liquid Limit:	-	27.8%
Plastic Limit:	-	13.9%
Plasticity Index:	-	14.0%
Water Content:	-	16.3%
Liquidity Index:	-	.17
Natural Unit Weight:	-	142.0 pcf
Ass'd. Spec. Gr.:	-	2.70 g/cm <sup>3</sup>
Void Ratio	-	0.38

The above data indicate the favourable engineering properties such as high shear strength combined with low compressibility and permeability. Occasionally more pervious silt and sand seams were encountered in the fine textured material.

A southwards sloping layer of very dense silt was encountered below the silty clay till. The stratum is very dense and has a low moisture content even below the ground water table. It is almost completely cohesionless and quite permeable due to its uniformity. For the grain size distribution, see enclosure #7.

VERY  
DENSE  
SILT

The deepest stratum explored in the present investigation is a concrete-hard glacial till consisting mainly of silt, sand and angular stones of various sizes and cemented by lime. The fact that the boreholes could only be advanced through this deposit by diamond drilling is an indication of its high density.

VERY  
DENSE  
CEMENTED  
SANDY  
SILT

The ground water table corresponded to the water level in the creek with the exception of borehole #2 where it was slightly higher, most probably due to seepage from above through the weathered and consequently more porous strata.

GROUND  
WATER

#### DISCUSSION AND RECOMMENDATIONS

It is understood that the proposed bridge will be a three-span structure, preferably of statically indeterminate design. It is the intention of the design engineer to support the centre piers on spread footings and the abutments on piles.

#### DESIGN

##### Piers

The bottom of the creek is at elevation 79.5 ft.; therefore the highest permissible foundation base level is at 75.5 ft. The strata at and below this grade are very dense; consequently an allowable bearing pressure of 10,000 is recommended which provides for a factor of safety greater than three against soil rupture. No measureable settlements are to be expected.

##### Abutments

The abutments can be supported on end bearing driven piles but attention is called to the very high density of the subsoil which may cause difficulties during driving. Timber piles would not penetrate below about elevation 85 ft. without damaging the pile tip. Therefore, if for hydrological reasons the piles have to extend to a lower elevation, we recommend that either driven steel H-bearing piles or bored caissons should be employed. The Hiley formula can be used in arriving at the safe bearing capacity of driven piles whereas the allowable bearing pressure is 20,000 psf for circular caissons provided their base level is below elevation 85 ft.

As an alternative, we suggest that the possibility of supporting the abutments on spread footings placed at higher levels should also be examined: the allowable bearing pressure is 10,000 psf at or below elevation 90 ft on the south side and at or below elevation 85 ft. on the north side.

Regardless of which of the three recommended foundation methods is employed, no appreciable settlements are anticipated.

It is obvious from the above conclusions that the site is quite suitable for designing a statically indeterminate structure.

#### CONSTRUCTION

The construction of the pier footings should be done by carefully planned dewatering. The river should be diverted during the construction of the footings which will prevent the inflow of water from above; however, water seepage will be experienced through the walls and the bottom of the excavation in the silt. To prevent the disturbance of the cohesionless silt subgrade, we recommend that the dewatering should be executed by lowering the water table in advance by pumping from deep wells established outside the footing area. Furthermore, as soon as the footing grade has been reached, the subgrade should be covered with a lean concrete blanket which would prevent the disturbance of the soil below the foundations.

If the abutments were supported on caissons whose base levels are below the ground water table, we suggest that the dewatering during construction should be done by pumping from deep wells established outside the area of the caissons. The bottoms of the wells should extend a couple of feet below the planned base levels of the caissons.

We trust that the foregoing will meet with your requirements but should you have any further questions in this regard, please do not hesitate to contact us.



LSR/oed

Encls.

Yours very truly,

DOMINION SOIL INVESTIGATION LIMITED,

A handwritten signature in cursive script that reads 'L. S. Rolko'.

L.S. Rolko, P.Eng., A.M. ASCE,

E n c l o s u r e s

# 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
$\phi > 8"$	$3"$	$3/4"$	$4.76\text{mm}$	$2.0$	$0.42$	$0.074$	$0.002 >$	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  
 " pressure : p  
 " tapping : t

OBSERVATIONS  
 MADE WHILE  
 CORING

Steady pressure  
 No pressure  
 Intermittent pressure

Washwater returns  
 Washwater lost

## PENETRATION RESISTANCES.

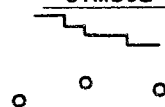
DYNAMIC PENETRATION RESISTANCE : to drive a 2"  $\phi$ , 60° cone attached to the end of the drilling rods into the ground, expressed in blows per foot.

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 :



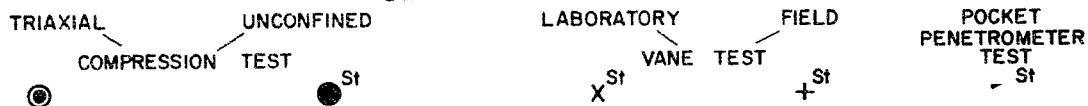
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## SOIL PROPERTIES.

W % Water content	$\gamma^*$ Natural bulk density (unit weight)	k Coeff. of permeability
LL % Liquid limit	e Void ratio	C Shear strength in terms of total stress
PL % Plastic limit	RD Relative density	$\phi$ Angle of int. friction in terms of effective stress
PI % Plasticity index	Cv 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%  
 10%  
 5%

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

## SOIL DESCRIPTION.

COHESIONLESS SOILS :

RD :

COHESIVE SOILS :

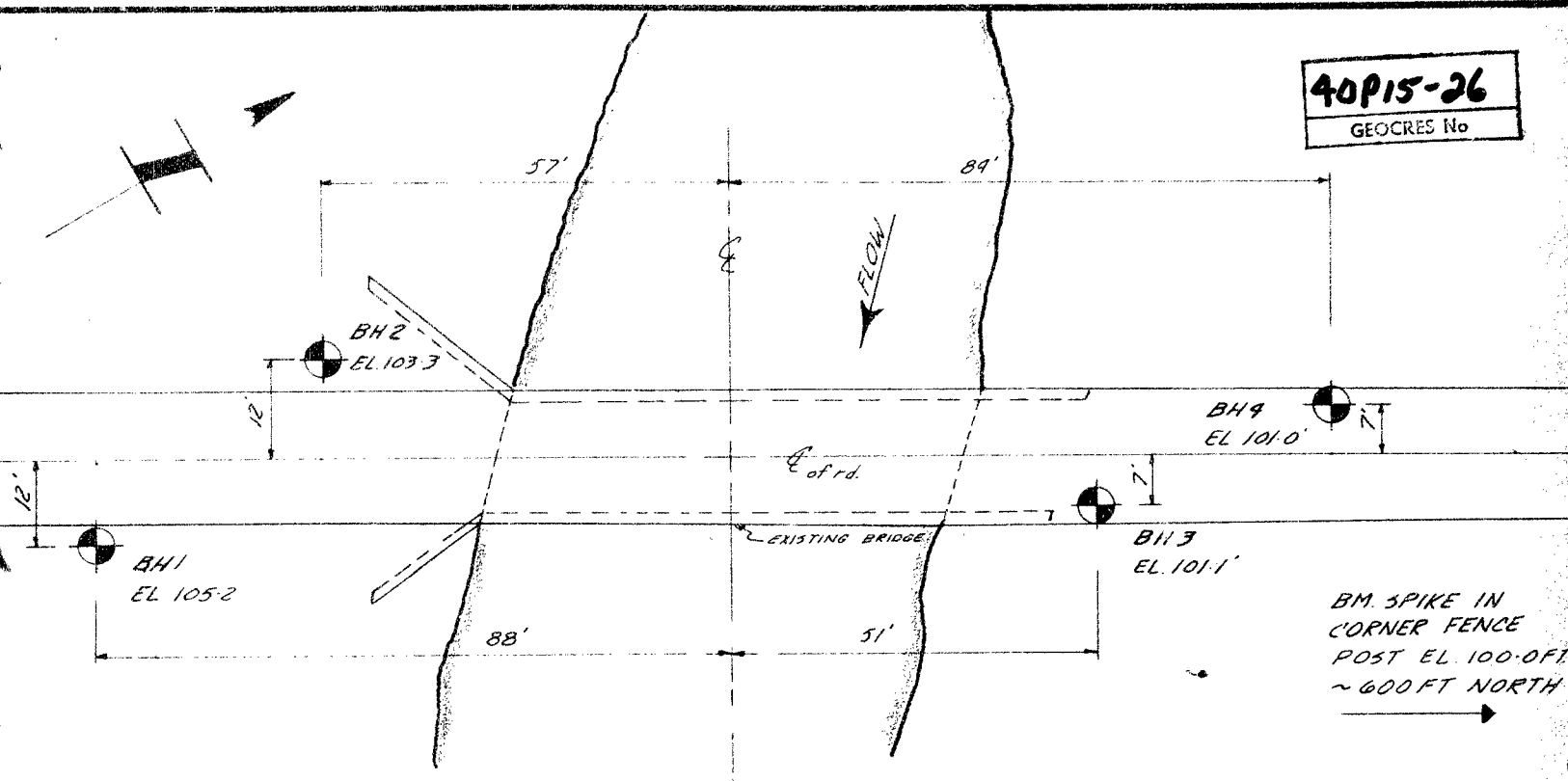
c lbs/sq.ft.

Very loose	0 - 15 %
Loose	15 - 35 %
Compact	35 - 65 %
Dense	65 - 85 %
Very dense	85 - 100 %

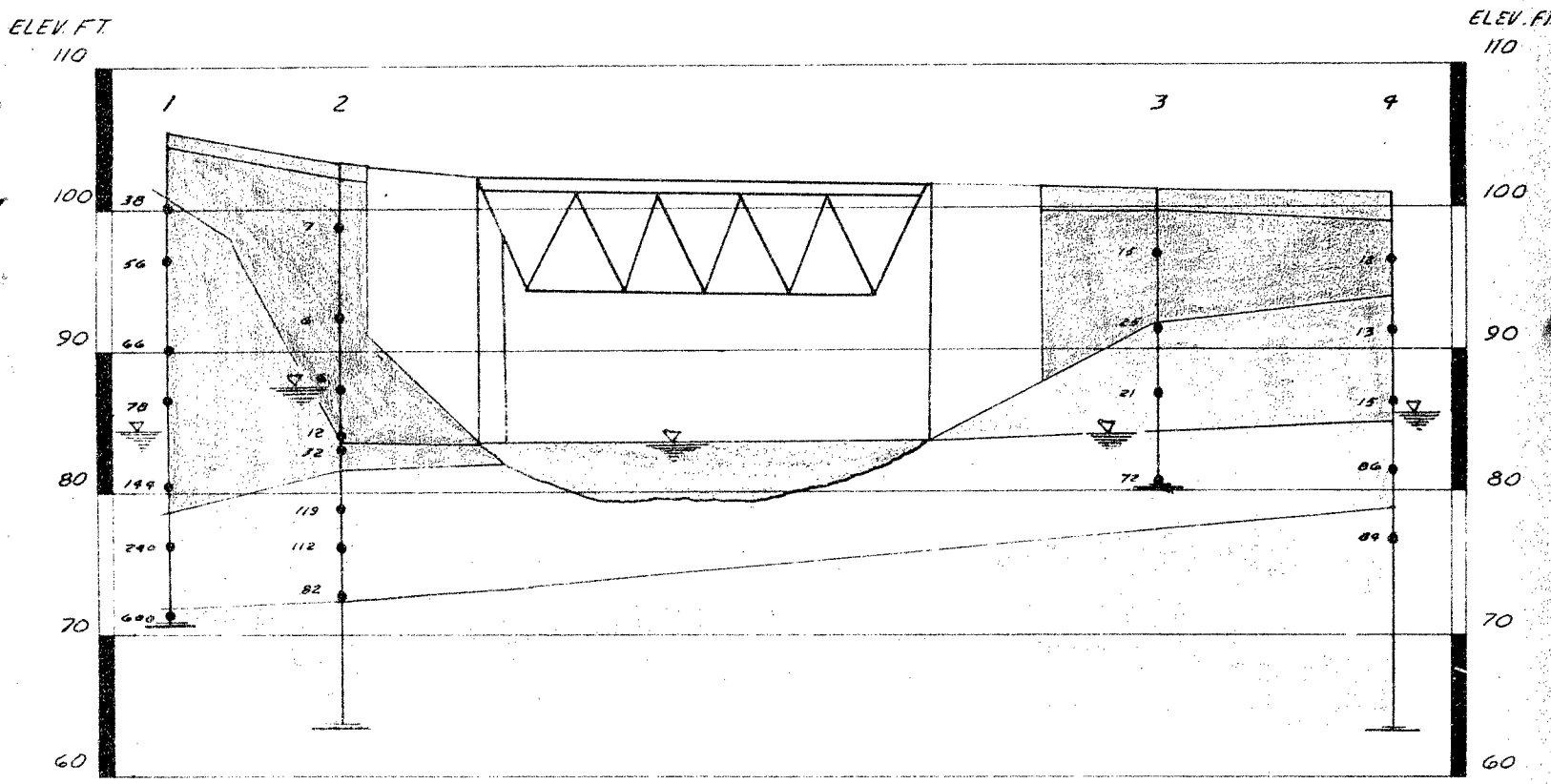
Very soft	less than 250
Soft	250 - 500
Firm	500 - 1000
Stiff	1000 - 2000
Very stiff	2000 - 4000
Hard	over 4000



**40P15-26**  
GEOCRE No



LOCATION OF BOREHOLES  
SCALE 1" TO 20'



SUBSURFACE PROFILE  
VERT SCALE 1" TO 10'

**LEGEND**

- |                                |                 |                                |
|--------------------------------|-----------------|--------------------------------|
| ROAD FILL                      | HARD SILTY CLAY | VERY DENSE CEMENTED SANDY SILT |
| LOAMY SAND, SILT AND CLAY FILL | VERY DENSE SILT | N VALUES                       |
|                                |                 | DENOTES END OF BOREHOLE        |

OUR REFERENCE NO. 4-1-6

# GEOTECHNICAL DATA SHEET FOR BOREHOLE ...3...

40P15-26

GEOCRESS INC.

CLIENT: MR. V.R. ASTROP CONSULTING ENGINEER  
PROJECT: ARNOLD BRIDGE

METHOD OF BORING: WASHBORING

DIAMETER OF BOREHOLE: 2 7/8"

ENCLOSURE NO. 5

LOCATION: COUNTY OF WELLINGTON ONT

DATE: FEB. 4, 1964

DATUM ELEVATION: SPIKE IN FENCE POST EL. 100.0 FT

ELEVATION ft.	DEPTH ft.	STRATIFICATION DESCRIPTION	STRATIFICATION SYMBOL	SAMPLES			PENETRATION RESISTANCE blows per foot					CONSISTENCY water content %				REMARKS		
				NUMBER	TYPE	N BY Advancement of Sampler	0	20	40	60	80	100	Pl	W	LI			
							SHEAR STRENGTH					lbs sq ft						
															20	40	60	80
101.1	0	ROAD FILL																
100.0		brown dry	N															
5		CLAYEY SAND	N	1	SS	15												
95		(fill)	N															
			N															
10			N	2	SS	25												
90		brown very stiff	N															
			N															
			N															
15		SILTY CLAY	N	3	SS	21												
85		with organics	N															
			N															
		grey wet very dense	N															
20		SILT	N	4	SS	72												
90																		
25																		

FEB 4 1964  
EL. 83.8

FEB 4 1964  
EL. 83.8

# GEOTECHNICAL DATA SHEET FOR BOREHOLE

40P15-26

GEOCREC No.

CLIENT MR. V.P. ASTROP CONSULTING ENGINEER

LOCATION WASHBORING

PROJECT ARNOLD BRIDGE

DATE OF TEST 278

COUNTY OF WELLINGTON ONT

DATE FEB 3-4, 1969

TEST METHOD SPIKE IN FENCE POST EL 100 FT.

ELEVATION FEET	DEPTH FEET	DESCRIPTION OF STRATIGRAPHY	PENETRATION SAMPLER	SAMPLER			PENETRATION RESISTANCE blows per foot					EXTRAPOLATED PENETRATION RESISTANCE blows per foot				REMARKS
				NUMBER	TYPE	SIZE	0	20	40	60	80	100	20	40	60	

105.2	0	ROAD FILL	00000														
		loamy															
		SILTY CLAY															
		FILL															
100.0	5			1	SS	38											
		brown hard															
95.0	10			2	SS	56											
		SILTY CLAY															
		with silt and															
		sand layers															
90.0	15			3	SS	66											
		and pockets															
85.0	20			4	SS	78											
80.0	25			5	SS	199											
		greyish wet very dense															
75.0	30			6	SS	240											
		SILT															
		with sand layers															
70.0	35			7	SS	600											
		but very dense cemented															
		SANDY SILT															

$\gamma = 142.0$   
P.C.F.

FEB 3, 1964  
EL. 84.5'

DETAILS OF  
EXTRAPOLATED  
PENETRATION  
RESISTANCES

Sa #	Blows
5	47/6" 60/5"
6	60/6" 67/6" 60/3"
7	57/6" 100/2"

$\gamma = 142.0$   
p.c.f.

FEB 3, 1969  
EL. 84.5'

DETAILS OF  
EXTRAPOLATED  
PENETRATION  
RESISTANCES

5a.7	Blows
5	47/6" 60/5"
6	60/6" 67/6" 60/3"
7	57/6" 100/2"

# GEOTECHNICAL DATA SHEET FOR BOREHOLE ... 2 ...

40P15-26

GEOCKAS INC.

DATE 4-1-6

MR. V. R. STROP CONSULTING ENGINEER  
PROJECT: ARNOLD BRIDGE

METHOD OF BORING: WASHBORING  
DIAMETER OF BOREHOLE: 2 1/8"

ENCLOSURE NO. 4

LOCATION: COUNTY OF WELLINGTON ONT.

DATE: JAN. 31 - FEB. 3, 1964

LOCATION: BETWEEN SPIKE IN FENCE POST EL 1000 FT

ELEVATION ft.	DEPTH ft.	STRATIFICATION DESCRIPTION	STRATIFICATION SYMBOL	SAMPLED			PENETRATION RESISTANCE Blows per ft.		CONSISTENCY water content, %		REMARKS	
				NUMBER	TYPE	N OF ACT. TESTS PER POINT	0	20	40	60		80
1033.0	0	ROAD FILL	0.9 0.9 0.0 0.0	1	CS	-						
	5	brown moist loamy SANDY CLAYEY SILT (fill)	M	2	SS	7						
	10		M	3	CS	-						
			M	4	TW	W						
			M	5	SS	6						
	15		2									
			2	6	SS	6						
			2									
	20	brown hard SILTY CLAY	0.9 0.9 0.0 0.0	7	SS	12						
						32						
	25	brown saturated very dense SILT		8	SS	119						
				9	SS	112						
	30			10	SS	82						
	35	buff very dense cemented SANDY SILT	6 Δ Δ Δ Δ	11	RC	45%						
			Δ	12	RC	45%						
	40		Δ Δ	13	WS	5						
			Δ Δ	14	RC	5						

FEB 4, 1964  
EL 87.3 FT

DETAILS OF  
EXTRAPOLATED  
PENETRATION  
RESISTANCE

5a"	Blows
8	39/6"
	47/6"
	60/5"

DYNAMIC PENETRATION TEST @  
BOTTOM OF  
BOREHOLE:  
100 blows/5 inches

VERTICAL SCALE 1 IN TO 5 FT

DOMINION SOIL INVESTIGATION LIMITED

MADE 2

CHD.

# GEOTECHNICAL DATA SHEET FOR BOREHOLE . . . 4 . . .

40P15-26

GEOTECH. No.

DATE: FEBRUARY 1969

ENGINEER: MR. V. R. ASTROP CONSULTING ENGINEER  
PROJECT: ARNOLD BRIDGE  
LOCATION: COUNTY OF WELLINGTON ONT  
DATUM ELEVATION: SPIKE IN FENCE EL 100.0 FT

METHOD OF BORING: WASHBORING  
DIAMETER OF BOREHOLE: 2 1/2"  
DATE: FEB 5, 1969

ENCLOSURE NO. 6

ELEVATION +	DEPTH -	STRATIFICATION DESCRIPTION	STRATIFICATION SYMBOL	SAMPLING			PENETRATION RESISTANCE Blows per foot					CONSISTENCY water content %				REMARKS	
				NUMBER	TYPE	% of water	SHEAR STRENGTH lbs/sq ft					PL	W	LI			
							0	20	40	60	80	100	20	40	60	80	
101.0	0																
100.0		ROAD FILL	0.0														
		brown dry	2.2														
95.0	5	CLAYEY FILL	2.2	1	SS	12											
			2.2														
90.0	10	dark brown stiff	2.2	2	SS	13											
		SILTY CLAY	2.2														
85.0	15	with organic remains	2.2	3	SS	15											
			2.2														
80.0	20	grey wet very dense SILT	2.2	4	SS	86											
			2.2														
75.0	25	buff very dense cemented	2.2	5	SS	89											
		SANDY SILT	2.2														
70.0	30	with cobbles	2.2														
			2.2														
65.0	35		2.2	7	RC	29%											
			2.2														
60.0	40		2.2	8	RC	67%											

FEB. 5, 1964  
EL. 85.3

SA. NO 6 WAS  
A WASH SAMPLE  
TAKEN FROM  
28'-6" TO 30'-0"  
DEPTHS

FEB 5, 1969  
EL. 85.3

SA. NO 6 WAS  
A WASH SAMPLE  
TAKEN FROM  
28'-6" TO 30'-0"  
DEPTHS

VERTICAL SCALE: 1 IN. TO 5 FT

DOMINION SOIL INVESTIGATION LIMITED

MADE: L.R.

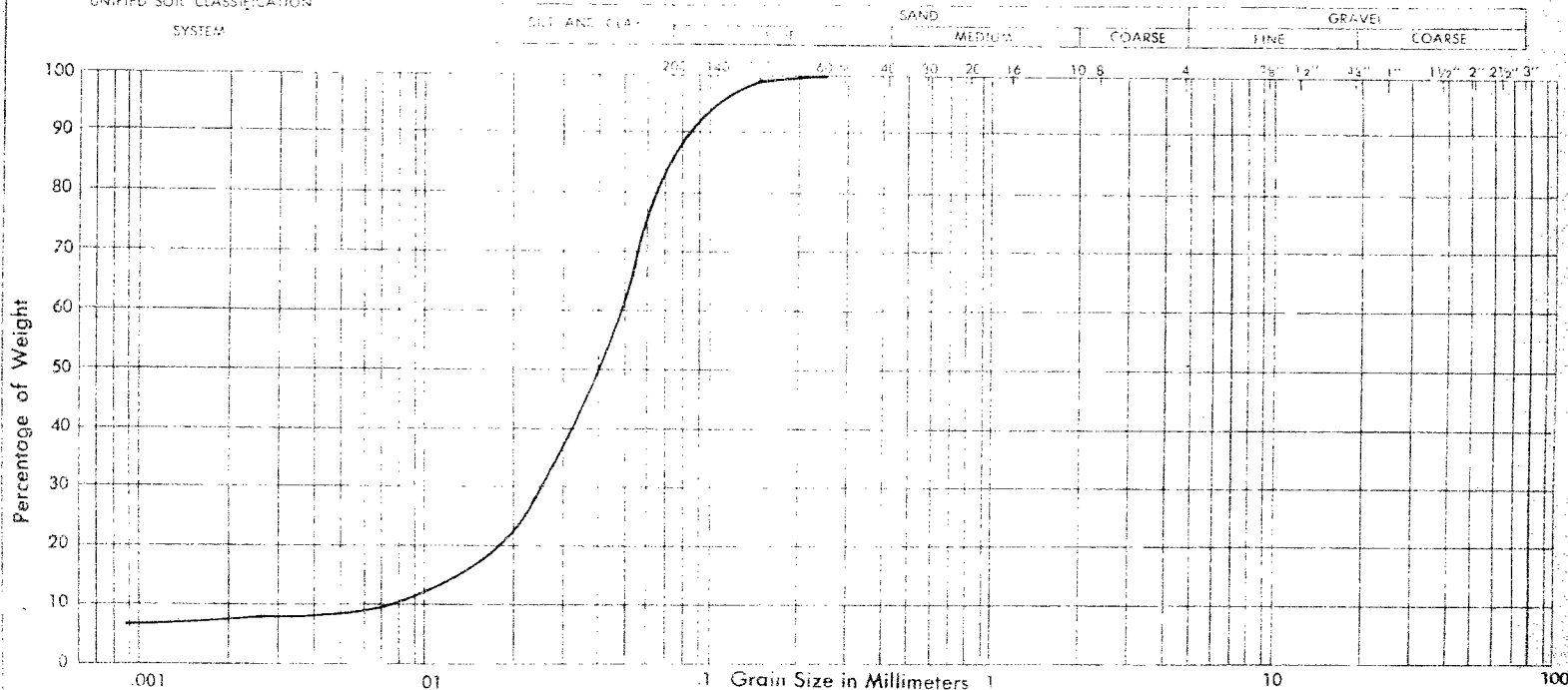
CH'D: R. R.

# DOMINION SOIL INVESTIGATION LIMITED

## GRAIN SIZE DISTRIBUTION

OUR REFERENCE NO. **4-1-6**

UNIFIED SOIL CLASSIFICATION  
SYSTEM



PROJECT **ARNOLD BRIDGE**  
 LOCATION **WELLINGTON COUNTY**  
 BOREHOLE NO. **2**  
 SAMPLE NO. **8**  
 DEPTH OF SAMPLE **25 feet**  
 ELEVATION OF SAMPLE **79.3 feet**

COEFFICIENT OF UNIFORMITY \_\_\_\_\_  
 COEFFICIENT OF CURVATURE \_\_\_\_\_

Classification of Sample and Group Symbol:

**SILT**

**ML**

PLASTIC PROPERTIES

LIQUID LIMIT \_\_\_\_\_ %  
 PLASTIC LIMIT \_\_\_\_\_ %  
 PLASTICITY INDEX \_\_\_\_\_ %  
 MOISTURE CONTENT \_\_\_\_\_ %  
 ACTIVITY \_\_\_\_\_

Enclosure No. 7