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W.P. No. _____

CONT. No. _____

W. O. No. _____

STR. SITE No. 35-23

HWY. No. _____

LOCATION TWP. RD. $\frac{1}{2}$ CREEK, 4 MI. SE.
OF THE TOWN OF MOUNT FOREST.

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. _____

REMARKS: DOCUMENTS TO BE UNFOLDED BEFORE
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DOMINION SOIL INVESTIGATION LIMITED
CONSULTING SOIL & FOUNDATION ENGINEERS
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40P15-23
C.P. No.

REPORT ON SUBSURFACE INVESTIGATION,
PROPOSED REPLACEMENT OF BRIDGE NO. 17,
TOWNSHIP OF ARTHUR,
MOUNT FOREST, ONTARIO.

STANDARD FILE NO. 35-23

Reference No. 76-4-K7

May 1976

Prepared for:

Township of Arthur,
c/o W.E. Kelley & Associates,
13 Spetz Street,
Kitchener, Ontario. N2H 1J9

Distribution:

- 6 copies - W.E. Kelley & Associates Limited
- 1 copy - Dominion Soil Investigation Limited (TORONTO)
- 1 copy - Dominion Soil Investigation Limited (KITCHENER-WATERLOO)



C O N T E N T S

	<u>Page No.</u>
1.0 INTRODUCTION	1
2.0 METHOD OF INVESTIGATION	1
3.0 THE SITE	2
4.0 SUBSOIL CONDITIONS	2
5.0 GROUNDWATER CONDITIONS	4
6.0 DISCUSSION	5
6.1 Steel Plate Pipe Arch	5
6.2 Box Culvert	6
6.3 Bridge on Spread Footings	8
6.4 Statement of Limitation	10

E N C L O S U R E S

Borehole Location Plan	Drawing No. 1
List of Symbols, Abbreviations and Nomenclature	Enclosure No. 1
Borehole Logs	Enclosures 2 & 3

1.0 INTRODUCTION

Dominion Soil Investigation Limited has been retained by W.E. Kelley & Associates Limited to conduct a subsurface investigation at the site of the proposed replacement of Bridge No. 17 in the Township of Arthur.

Authorization to proceed with the work was received in a letter dated April 7, 1976 from W.E. Kelley, P. Eng., of W.E. Kelley & Associates Limited, Consulting Engineers for the project.

The purpose of the investigation was to disclose the subsurface conditions at the site and make recommendations for the design and construction of the foundations for the proposed structure. As a result of the subsurface conditions and a further discussion with the Consulting Engineers, a discussion has been included in this report regarding the type of structure to be used in this location.

2.0 METHOD OF INVESTIGATION

The field work consisted of 2 exploratory boreholes put down at the locations shown on Drawing No. 1 of this report. The boreholes were advanced to the sampling depths using a continuous flight hollow stem power auger and samples of the subsoil were

recovered at 2½ and 5 foot intervals in depth in each of the boreholes using the Standard Penetration Test Method. The samples recovered were returned to our laboratory for visual and tactile examination.

The elevations have been referred to a local benchmark provided by the Consulting Engineers. The benchmark used was a nail in a cedar tree, 115 feet south of the proposed bridge and it has been assigned an assumed elevation of 100.0 feet referenced to local datum.

3.0 THE SITE

The site is located in the Township of Arthur approximately 4 miles south-east of the Town of Mount Forest. The township road crosses a small creek which is approximately 20 feet wide at the crossing. The existing bridge is located in a wide flat valley through which the stream meanders and the existing structure is in a poor state of repair.

4.0 SUBSOIL CONDITIONS

The subsoil conditions encountered in the two boreholes differed considerably.

It is apparent that the north side of the creek is filled with out-wash sand and gravel whereas the south side of the creek is part of a kame moraine deposit associated with the area. Details of the subsoil conditions encountered in each borehole are given on the individual borehole logs of Enclosures 2 & 3 and may be discussed briefly below.

- (i) FILL - The upper 2 feet consisted of sand and gravel fill and is the present road surface. Beneath this, dense to very loose black silt with organics was encountered extending to a depth of 5 and 7 feet respectively in the two boreholes. In BH 2, logs were encountered at a depth of 6 to 7 feet. 'N' values within the fill ranged from 4 to 36 blows per foot.
- (ii) CLAYEY - In BH 1 a layer of clayey silt was encountered
SILT extending from beneath the fill to a depth of 18 feet. The consistency of the clayey silt was firm to hard and the colour varied from brown to grey. 'N' values within the clayey silt ranged from 6 to over 100 blows per foot and the occasional pebble giving a till like structure was encountered.

- (iii) SAND - Beneath the fill in BH 2 and underlying the clayey silt in BH 1, compact to very dense brown and grey medium sand with a trace of gravel was encountered. Both boreholes were terminated within the sand stratum and it was apparent from the sand in the stem of the augers that the sand was under a slight upward hydrostatic pressure. 'N' values within the sand ranged from 10 to over 100 blows per foot.

5.0 GROUNDWATER CONDITIONS

The free surface of the groundwater table was encountered at Elevation 95± which approximated the level of the water in the creek at the time of the investigation.

6.0 DISCUSSION

Several alternatives for the creek crossing have been proposed by the Consulting Engineers and the decision between each type of structure will be partly based on the economy of construction. A steel pipe arch, a box culvert or a simply supported bridge on spread footings are being considered and each will be discussed with respect to foundation conditions in the following sections.

6.1 Steel Plate Pipe Arch

Steel plate pipe arches are generally placed according to the manufacturers instructions. It is customary that they are bedded on compacted granular fill and then backfilled with similarly compacted granular fill up the underside of the roadway. The degree of compaction and a selection of the material to be used for backfill is generally specified by the manufacturer.

It is proposed to place the bedding for the pipes at such an elevation that the invert of the pipe will be at Elevation 92. At this level, the bedding will rest partly on stiff clayey silt in the vicinity of BH 1 and partly on compact medium sand near BH 2. The settlement characteristics of each are different

and if the site is adequately dewatered, the differential settlement between the sand and clayey silt will be minimal. It is expected that the differential settlement will approach 1 inch which is considered tolerable for this type of structure.

Dewatering is necessary prior to excavation and should consist of diverting the stream and installing several gravity sumps extending to Elevation 90 in the sand layer to provide adequate dewatering. If the sand is not dewatered it will be unstable and will rapidly lose strength when excavated. Each sump should be placed in the sand layer as mentioned, and should be filtered with a fine granular soil. Excavation can commence after dewatering has been accomplished and the sides of the excavation should be sloped back to 45° to achieve stability.

The upstream approach should be lined with rip-rap to reduce the incidence of scour and prevent undermining of the sand layer.

6.2 Box Culvert

A box culvert is usually formed as a unit and can be supported on soil of a lesser bearing capacity than a conventional bridge.

The foundations for the box will be at Elevation 89.5 according to the Consulting Engineers and it is suggested that a working slab consisting of lean concrete be placed at Elevation 89, prior to forming the foundations and base slab of the box culvert.

The safe net bearing pressure at this level is 1000 p.s.f. provided that dewatering is done prior to excavation. Dewatering will be similar to that provided in the previous section and the sumps should extend to Elevation 87. This is considered within the capabilities of the gravity sumps in the medium sand.

It is important that the sand be dewatered to prevent disturbance and minimize the differential settlements.

Curtain walls will be required upstream to prevent scour and these should extend 4 feet deeper (to Elevation 85). More extensive local dewatering will probably be required in order to install these curtains walls but it is conceivable that gabions could be used which can be installed below the water table. Concrete could also be placed below the water table if necessary.

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Excavations, if dewatered properly, can be sloped back to 45° to achieve a stable configuration and stream bed diversion is necessary.

The backfill around the structure should consist of well compacted Granular 'B' (M.T.C. Specification 1010) and the recommended compaction is 95% Standard Proctor Maximum dry density. Over compaction should be avoided and it is suggested that the backfill be drained to prevent the build-up of hydrostatic pressure. Rip-rap protection may also be required on the upstream faces of the excavation.

6.3 Bridge on Spread Footings

The bridge alternative will consist of a simply supported deck on cantilever retaining walls placed on spread footings. It is recommended that the spread foundations extend to 5 feet below stream bed (Elevation 87). At this level a safe net bearing pressure of 3000 p.s.f. is recommended. Dewatering is mandatory and it should consist of well-points in the sand layer as this depth is well beyond the capabilities of gravity sumps. Creek diversion is also necessary.

If the sand is adequately dewatered prior to construction and disturbance is kept to a minimum, differential settlement between the two abutments will be approximately 1 inch. It is imperative that the disturbance be kept to a minimum to maintain differential settlement within the tolerable limit.

The excavations will be up to 14 feet deep and the sides can be sloped back to 45° if the site is dewatered by well-points. The backfill around the structure should consist of Granular 'B' compacted to 95% Standard Proctor Maximum Dry Density and through-drains in the wall are recommended to prevent the build up of hydrostatic pressure.

As it is anticipated that the foundation conditions for spread footings are difficult it is conceivable that the proposed structure could be supported on driven piles. Driven timber piles would meet the required set near El. 80± and size 14 (12" diameter) croesoted piles could generate a safe load of 25 tons per pile if driven to practical refusal according to the Hiley formula.

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Other types of piles are also suitable and more detail can be provided if this type of foundation is considered.

6.4 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 groundwater conditions between and beyond the boreholes may differ from those encountered at the boreholes and conditions may become apparent during construction which could not be anticipated or detected by the soil investigation.

We recommend that a geotechnical engineer or other designated inspector from this company should be called upon to visit every excavation or other type of earth-work associated with this project where the soil is required to support load.

The inspector should be given ample opportunity to verify that the conditions encountered by the construction are similar to those described in the report, and to confirm that the conclusions and recommendations of the report are not invalidated by new information that may have come to light during construction.

If such confirmation cannot be given, the foundation design should be reviewed with respect to the new information.

In cases where the foregoing recommendation is not followed, the company's responsibility is limited to interpreting accurately the information encountered at the boreholes.

DOMINION SOIL INVESTIGATION LIMITED.



J. Byron England, P. Eng.,
Kitchener-Waterloo Branch Manager

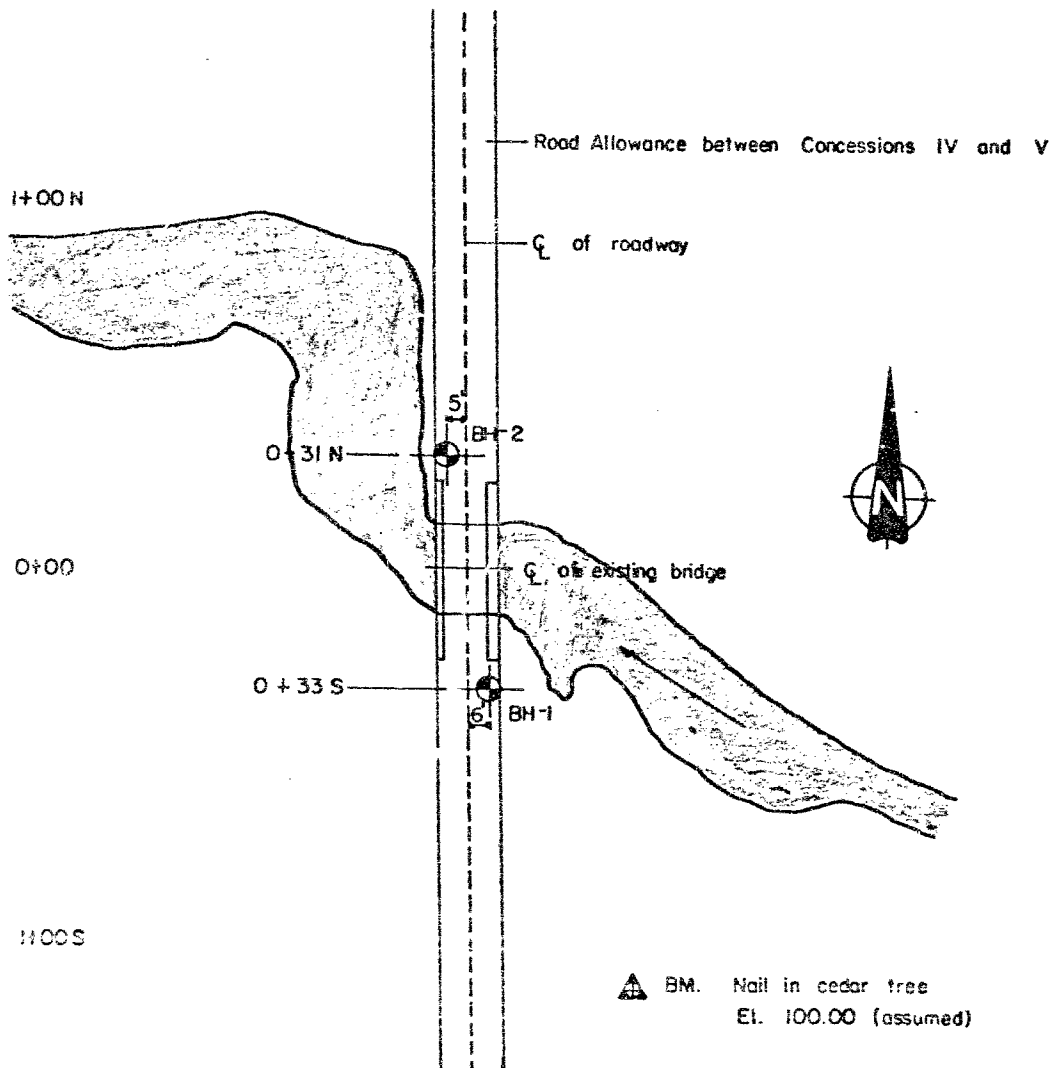
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Prep. By KM



BOREHOLE LOCATION PLAN

SCALE: 1" = 50'

DOMINION SOIL INVESTIGATION LIMITED

LIST OF SYMBOLS, ABBREVIATIONS AND NOMENCLATURE

SOIL COMPONENTS AND GROUND WATER CONDITIONS

												Ground Water Level
BOULDER	COBBLE	GRAVEL		SAND			SILT	CLAY	ORGANIC	BEDROCK		Depth of Core-in
Ø	8"	coarse	fine	coarse	medium	fine					no size limit	
		4"	3/4"	4.75mm	2.0	0.42	0.075	0.002				

SAMPLE TYPES

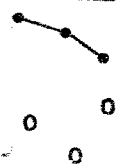
AS	Auger Sample	SS	Split Spoon Sample
RC	Rock Core	TP	Piston, thin walled tube sample
%	Recovery	TW	Open, thin walled tube sample

PENETRATION RESISTANCES

DYNAMIC PENETRATION RESISTANCE: to drive a 2" Ø, 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, using a 140 lb hammer falling 30 inches

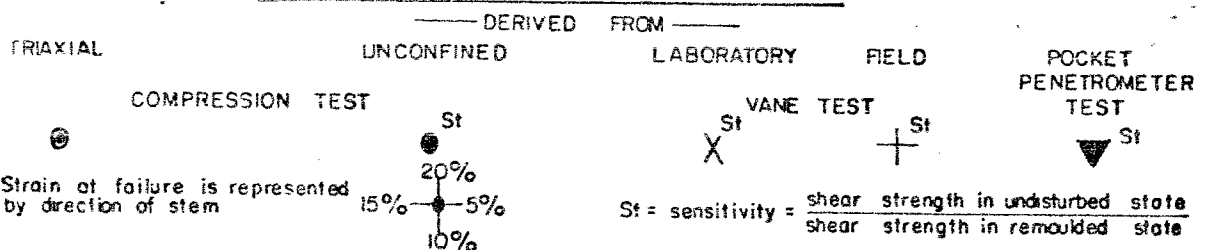
SYMBOL



SOIL PROPERTIES

W%	Water content	k	Coeff. of permeability
LL%	Liquid limit	C	Shear strength
PL%	Plastic limit	φ	Angle of int. friction
γ	Natural bulk density (unit wt.)	φ'	Cohesion
C _v	Coeff. of consolidation	φ'	Angle of int. friction

UNDRAINED SHEAR STRENGTH



LOG OF BOREHOLE 1





Our Reference No. 76-4-K7

Enclosure No. 2

CLIENT: Township of Arthur
PROJECT: Replacement of Bridge Number 17
LOCATION: Conc. 4 and 5, Twp. of Arthur
DATUM ELEVATION: Local

DRILLING DATA

Method: Augering
Diameter: 6 1/2"
Date: April 15, 1976

SUBSURFACE PROFILE				SAMPLES			PENETRATION RESISTANCE Blows/Ft.					WATER CONTENT %			REMARKS	
ELEVATION Ft.	DEPTH Ft.	DESCRIPTION	SYMBOL	GROUND WATER	NUMBER	TYPE	'N' Blows/Ft.	20	40	60	80	100	PLASTIC LIMIT	NATURAL		LIQUID LIMIT
								UNDRAINED SHEAR STRENGTH p.s.f.					W _p	W		W _L
								+ FIELD VANE TEST • COMPRESSION TEST								
100.9	0	GROUND SURFACE														
		SAND and GRAVEL (Fill)														
98.9	2.0	Compact black SILT with organics (Fill)			1	SS	19									
95.9	5.0	 Firm to hard brown grey			2	SS	6	0								
					3	SS	23		0							
	10	clayey SILT			4	SS	33		0							
	15	occasional pebble			5	SS	>100									
82.9	18.0	very dense grey			6	SS	62									
	20	medium SAND														
		trace gravel														
75.9	25	END OF BOREHOLE														

EL. 949
April 15, 1976

LOG OF BOREHOLE.....2.....

Our Reference No. 76-4-K7

Enclosure No. 3

CLIENT: Township of Arthur
PROJECT: Replacement of Bridge Number 17
LOCATION: Conc. 4 and 5, Twp. of Arthur
DATUM ELEVATION: Local

DRILLING DATA

Method: Augering
Diameter: 6 1/2"
Date: April 15, 1976

SUBSURFACE		PROFILE		SAMPLES			PENETRATION RESISTANCE					WATER CONTENT			REMARKS	
ELEVATION Ft.	DEPTH Ft.	DESCRIPTION	SYMBOL	GROUND WATER	NUMBER	TYPE	'N' Blows/Ft.	Blows/Ft.					%			
								20	40	60	80	100	PLASTIC LIMIT W _p	NATURAL W		LIQUID LIMIT W _L
								UNDRAINED SHEAR STRENGTH p.s.f.								
								+ FIELD VANE TEST • COMPRESSION TEST								
101.1	0	GROUND SURFACE														
		SAND and GRAVEL (Fill)												Initial BH2 encountered log at 7.5'		
99.1	2.0	Dense to very loose black SILT with organics (Fill)														
		logs 6'-7'														
	5															
	7.3															
	10	Compact to very dense brown medium SAND														
	15	Some gravel														
	20															
	25															
	26.0	END OF BOREHOLE														
							</									