#
58-F-261C
COUNTY RD. BRIDGE
OVER E. BRANCH
BLACK CREEK

BA 841

58-F-261.C

TROW, SODERMAN AND ASSOCIATES

SITE INVESTIGATIONS
AND
SOIL MECHANICS CONSULTATION

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ST. 8-5921

Project: J304

November 24, 1958

Mr. A. M. Toye,
Bridge Engineer,
Department of Highways of Ontario,
280 Davenport Road,
Toronto, Ontario.

Attention: Mr. J. McAllister

Foundation Investigation
County Road Bridge over East Branch of Black Creek,
Lot 30 - Enniskillen Township, Lambton County.

Dear Sirs:

Enclosed herewith is our report on the soil conditions encountered at the bridge crossing of Black Creek East in the County of Lambton.

Reference to this report indicates that no foundation problems should be anticipated either from creek scour or from inadequate bearing. Abutment footings can be placed in unshored dry excavations dug 5 feet below river bed level and the recommended safe bearing value here is 8000 psf.

If your plans for this structure deviate significantly from the assumptions made in this report, we shall be pleased to review your proposals with regard to possible effects on the soil. In view of the very stiff condition of the soil, however, the possibility of overstressing appears unlikely.

It is our pleasure, again, to be of service to you.

Yours very truly,

W.A. Trow

William A. Trow (P. Eng.)

WAT/kb
ENC.

DEPARTMENT OF HIGHWAYS OF ONTARIO
280 DAVENPORT ROAD,
TORONTO, ONTARIO.

FOUNDATION INVESTIGATION
COUNTY ROAD BRIDGE OVER EAST BRANCH OF BLACK CREEK, LOT 30 - ENNISKILLEN TOWNSHIP, LAMBTON COUNTY.

Project: J304 November 24,1958

Trow Soderman and Associates

TABLE OF CONTENTS

- - - - - - -

ENCLOSURES

Foundation Investigation
County Road Bridge over East Branch of Black Creek,
Lot 30 - Enniskillen Township, Lambton County.

This report describes the results of a foundation investigation completed recently for the above noted creek crossing of the county road dividing Concession 4 and 5 in Enniskillen Township. Recommendations concerning permissible bearing values and suitable foundation depths have been given.

Site Description

The site under consideration lies in flat farm country typical of the clay till plain of this part of south western Ontario. The creek consists essentially of a drainage ditch some 7 to 8 feet deep extending through the farmland to the north east and south west. It carries off the water from other subordinate ditches used to drain this very flat land. The present depth of water is about 1 foot and is extremely sluggish. Adjacent residents, however, indicate that the spring run-off fills the ditch and in living memory has flooded the road. Despite this fact little erosion appears to have taken place. The depth of scour is limited to a granular bed about 1 foot thick and this is underlain by the very stiff dry clay noted in the adjacent borings. This information was obtained by digging with a shovel in three representative locations.

The existing bridge represents a temporary replacement of a concrete structure, the centre portion of which has been collapsed into the creek. It now consists of two badly deteriorated concrete abutments spanned by a system of simple wood beams, I beams and channels. The west abutment appears to have been undercut somewhat but this may be due to deterioration of original poor quality concrete.

Field Sampling Methods

The four borings of this investigation were performed using conventional diamond drill equipment adapted for soil sampling purposes. The boreholes were cased with 3-inch pipe although this casing was not driven to full sampling depth because of the extremely compact adhesive nature of the soil. The locations of the four borings are shown in drawing 1. Each borings was taken to a maximum depth of 26½ feet although sampling in hole 4 was terminated at 19 feet.

Samples were taken at 5 foot intervals of depth, and, because the soil was very stiff, they were obtained for the most part in the disturbed state using a 2-inch O.D. split spoon. Undisturbed 2-inch I.D. Shelby tube samples, however, were taken just below estimated foundation depth in holes 2 and 4 and these specimens were subsequently subjected to laboratory strength tests. The soil was too stiff for field vane measurements of shear strength.

Penetration and washing of the material in the borings was extremely difficult and attempts were made to clear the soil between sampling intervals by taking almost continuous samples. The high resistance to wash water appears to confirm visual observations of the creek bed concerning its high resistance to scour.

The elevation of each borehole was referred to existing creek level, which was assumed to be at elevation 668 feet. The field work was supervised at all times by the author.

Description of Soil Types

The soil at all test locations was very similar in physical character and was identified as a glacial till deposit consisting of very stiff grey silty clay with tiny pebbles. The consistency or stiffness appeared to be uniform at each location and for the entire test depth of 26 feet. The topsoil cover was somewhat variable ranging from at least 2½ feet in hole 1 to 1 foot at the other locations. The underlying clay till was oxidized to a brown colour in the first approximately 5 feet of holes 1 and 2.

Laboratory tests, performed shortly after work was completed, indicated that the shear strength of the soil ranged from about 3500 to 4400 psf. The natural moisture content of the soil showed little variation and was at or close to its plastic limit. This fact provides additional confirmation of its very stiff competent state and is in agreement with field penetration measurements. Cohesive soils at this lower end of the plastic range are considered to have a low degree of compressibility. The liquid limit of the till was in the order of 31 to 36 percent which classifies it as a clay of medium plasticity.

Foundation Considerations

In the consideration of permissible bearing pressures and foundation depths at this site, it is assumed that the proposed replacement structure will not vary in weight significantly from the existing or original bridge over this creek. With this in mind and considering the very stiff, competent conditions at all test locations, the support of the abutments directly on the clay till would appear quite justified. The design of the abutments requires only a knowledge of the strength and compressibility of the soil and a decision concerning the possible future extent of creek bed scour.

The opinion concerning the latter problem is that scour activity will be limited to very shallow depths and therefore that a foundation bearing 5 feet below river bed level will provide adequate protection in this regard. This opinion is based upon the belief that the velocity of flow should not be great even during spring run-off and that the clay till has a very high resistance to erosion. This latter view is supported by observations of the extent of scour in the existing creek bed and more particularly by the great difficulty encountered in washing out this very adhesive clay during the field sampling program.

The evaluation of permissible bearing values is based specifically upon measurements of undrained shear strength and is determined from the relationship

$$Q = \frac{C\ N_c}{F.S.} + \gamma d$$

where C = undrained shear strength found here to range from 3500 to 4400 psf.

N_c = bearing capacity factor equal approximately to 7 for the rectangular abutment footings required.

γd = surcharge weight above footing level.

F.S. = required factor of safety to ensure that settlement, due to consolidation and plastic readjustment, is kept within tolerable limits. For the conditions of very stiff soil and relatively narrow footing size required, this settlement requirement will be satisfied through the use of a factor of safety of three.

Assuming therefore that the foundation lies 5 feet below river bed level the permissible safe bearing value for this site is at least equal to 8000 psf. Settlement under this pressure should be much less than 1 inch. This latter opinion is based not only upon the use of a factor of safety of three but also upon the fact that the soil moisture content lies at or close to its plastic limit. This competent soil condition was confirmed for a depth of at least 19 feet below required foundation level. Bearing stresses from abutment footings will be reduced to negligible values at this depth.

Although the ground water table here is probably coincident with the surface of the creek, the clay till is so impermeable and stiff that the excavation for the abutment footings can be carried out in the dry without the use of shoring. Some minor redirection of the creek may by required to prevent its entry into the excavation. Concrete should be poured directly into these footing pits shortly after digging operations have ceased. Gradual softening of the clay till will thereby be avoided.

Horizontal earth pressures against the bridge abutments will vary somewhat with time and with the type of structure proposed. If the concrete is poured directly against the clay face, the initial pressure will correspond to the "at rest condition" in which the unit stress will be approximately 0.7 times the overburden weight at any depth. In actual fact, however, this pressure cannot be considered as a force shoving out against the abutments since any tendency for the clay to move will be resisted by its own high cohesive resistance. As time progresses, this pressure will diminish to the active state which, again, should be negligible. Horizontal thrust from other sources such as truck traffic will be resisted by the passive resistance of the clay till against the backs of the abutments and by the full cohesive resistance generated along the clay - footing base contact. The passive resistance per lineal foot of abutment can be determined conservatively from the expression

$$P = \tfrac{1}{2}\gamma h^2 + 2Ch$$

where γh = overburden pressure from the road surface to the base of the footing, γ being equal approximately to 135 pcf.

C = cohesion estimated here to be about 4000 psf for the stiff brown upper clay.

Recommendations

The conclusions and recommendations arising out of the foregoing comments concerning subsoil conditions at this site are as follows:

1) The subsoil at this site to a depth of at least 26 feet consists of very stiff silty clay glacial till.

2) Abutment footings, if founded 5 feet below river bed level should be quite unaffected by scour. The safe bearing value at this depth is 8000 psf and the settlement associated with the use of this pressure will be less than 1 inch.

3) Excavation for the abutment footings can be carried out "in the dry" without use of shoring.

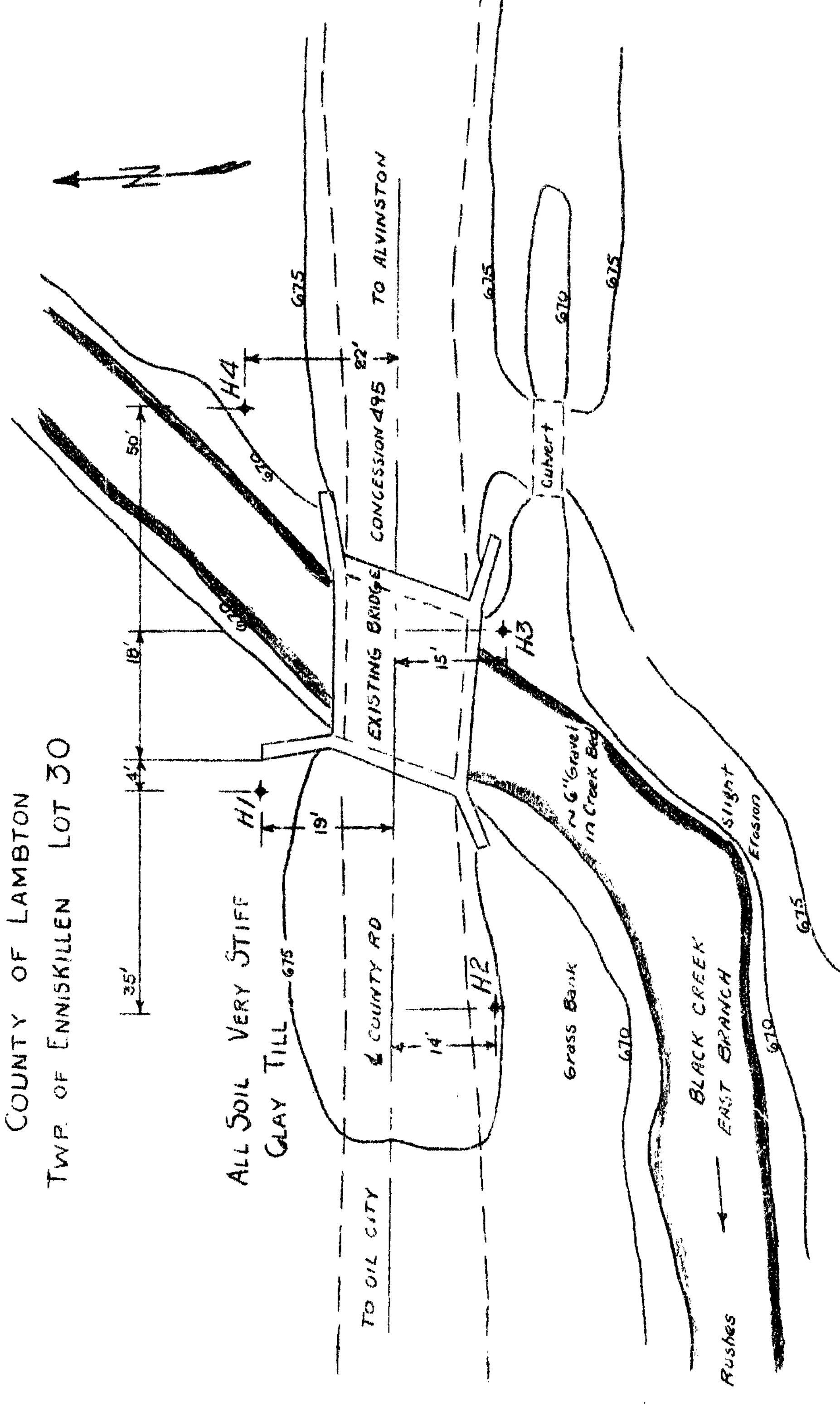
WA Trow

WAT/kb

William A. Trow (P. Eng.)

REGISTERED PROFESSIONAL ENGINEER
CIVIL
W. A. TROW
PROVINCE OF ONTARIO

PROJECT NO. J304 DRAWING NO. 1



Sketch of Site Showing Borehole Locations
(overlay D.H.O. Plan E3529-1, scale 1"=20')

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PROJECT NO. J304

DRAWING NO. 2

TROW SODERMAN AND ASSOCIATES

SITE INVESTIGATIONS AND SOIL MECHANICS CONSULTATION

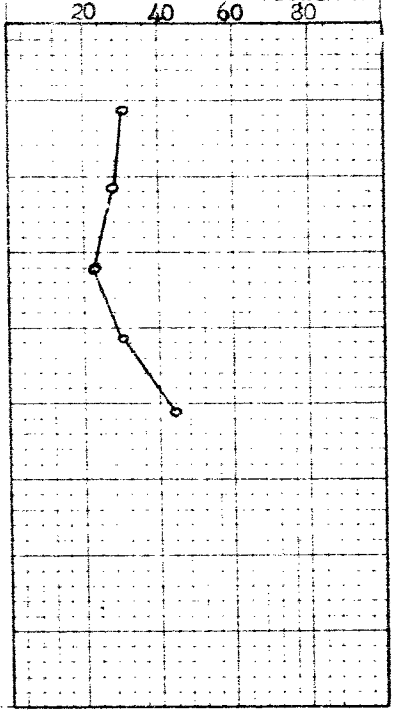
LEGEND

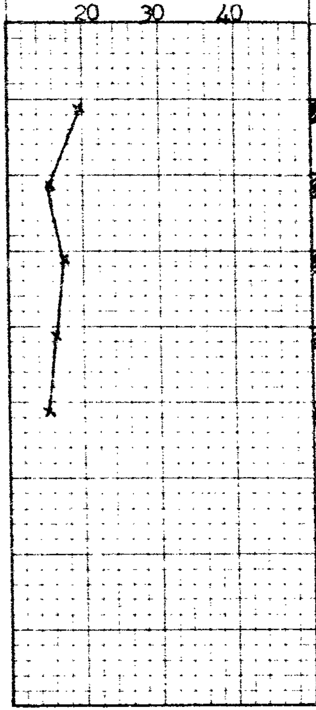
- 2" DIA. SPLIT TUBE
- 2" SHELBY TUBE
- 2" SPLIT TUBE
- 2" DIA. CONE
- CASING
- 2" SHELBY
- 1/2 UNCONFINED COMPRESSION (Qu) ⊕
- VANE TEST (C) AND SENSITIVITY (S) +S
- NATURAL MOISTURE AND LIQUIDITY INDEX X LI
- LIQUID LIMIT
- PLASTIC LIMIT

PROJECT County Rd.Bridge,Black Creek East,
LOCATION Enniskillen Twp. Lot 30
HOLE LOCATION See Dwg. 1
HOLE ELEVATION AND DATUM 674.7

BOREHOLE NO. 1
FIELD SUPERVISOR W.T.
DRILLER E.A.
PREP. W.T.

SYMBOL	DESCRIPTION	ELEV. FEET	DEPTH FEET	STRENGTH AND PENETRATION RESISTANCE P.S.F. / BLOWS/FT. 20 40 60 80	CONSISTENCY MOIST. CONTENT- % DRY WT. 20 30 40	SAMPLE	NATURAL UNIT WT. P.C.F.
	Ground surface.	674.7	0				
	Very stiff dry clayey topsoil.	~672					
	Glacial Till. Very stiff to hard brown silty clay with tiny pebbles up to ¼ inch, changing to dark grey at 5 ft. and to grey at about 10 ft.		10			SS1	
						SS2	
						SS3	
			20			SS4	
						SS5	
	End of bore.	648					
			30				





Note: Soil quite impermeable, no water table measurement possible.

PROJECT NO. J304

DRAWING NO. 3

TROW SODERMAN AND ASSOCIATES

SITE INVESTIGATIONS AND SOIL MECHANICS CONSULTATION

PROJECT County Rd.Bridge, Black Creek East,
Enniskillen Twp. Lot 30
HOLE LOCATION See dwg. 1
HOLE ELEVATION AND DATUM 675.6

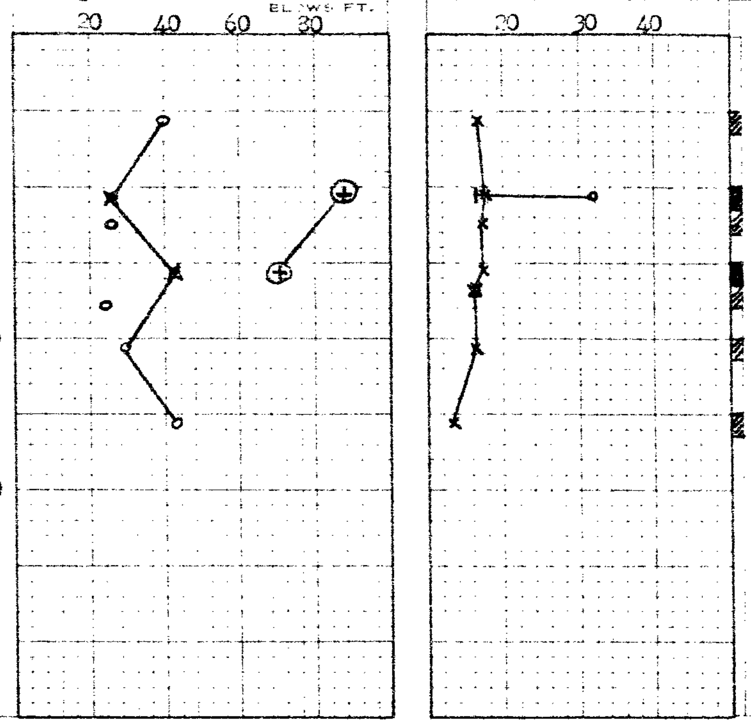
BOREHOLE NO. 2
FIELD SUPERVISOR W.T.
DRILLER E.A.
PREP W.T.

LEGEND
2" DIA. SPLIT TUBE
2" SHELBY TUBE
2" SPLIT TUBE
2" DIA. CONE
CASING
2" SHELBY
1/2 UNCONFINED COMPRESSION (Qu) ⊕
VANE TEST (C) AND SENSITIVITY (S) +S
NATURAL MOISTURE AND LIQUIDITY INDEX X LI
LIQUID LIMIT
PLASTIC LIMIT

SYMBOL	DESCRIPTION	ELEV. FEET	DEPTH FEET
	Ground surface.	675.6	0
	Stiff clayey topsoil.	674.6	
	Glacial Till. Very stiff to hard brown silty clay with pebbles, changing to grey in colour below about 7 ft.		
	End of bore.	649	

STRENGTH AND PENETRATION RESISTANCE — Shear Strength 2000 4000 P.S.F.; BLOWS FT. 20 40 60 80

CONSISTENCY — MOIST. CONTENT- % DRY WT. 20 30 40



SAMPLE	NATURAL UNIT WT. P.C.F.
SS1	
TW2	137.5
SS2A	
TW3	138.0
SS3A	
SS4	
SS5	

PROJECT NO. J304

DRAWING NO. 4

TROW SODERMAN AND ASSOCIATES

SITE INVESTIGATIONS AND SOIL MECHANICS CONSULTATION

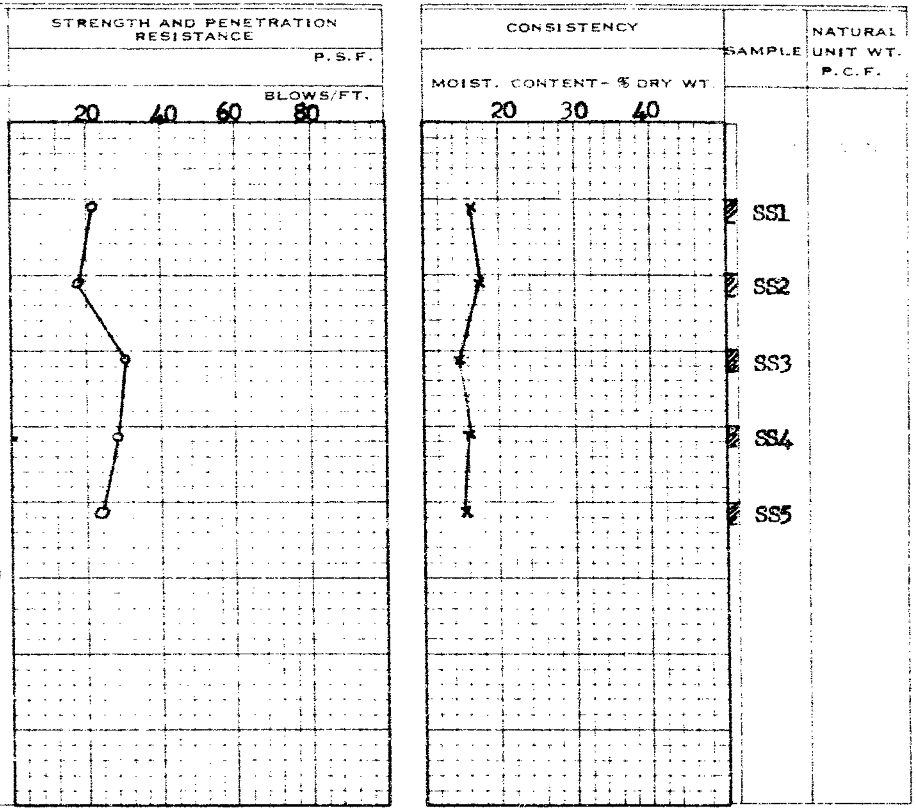
LEGEND

- 2" DIA. SPLIT TUBE
- 2" SHELBY TUBE
- 2" SPLIT TUBE
- 2" DIA. CONE
- CASING
- 2" SHELBY
- 1/2 UNCONFINED COMPRESSION (Qu)
- VANE TEST (C) AND SENSITIVITY (S)
- NATURAL MOISTURE AND LIQUIDITY INDEX
- LIQUID LIMIT
- PLASTIC LIMIT

PROJECT County Rd.Bridge, Black Creek East,
LOCATION Ehniskillen Twp. Lot 30
HOLE LOCATION See dwg. 1
HOLE ELEVATION AND DATUM 668.8

BOREHOLE NO. 3
FIELD SUPERVISOR W.T.
DRILLER E.A.
PREP. W.T.

SYMBOL	DESCRIPTION	ELEV. FEET	DEPTH FEET
	Ground surface.	668.8	0
	Approx. 1 ft. clay sod.		
	Glacial Till. Very stiff grey silty clay with small pebbles.		
			10
			20
	End of bore.	642	
	Note: Till very stiff below elevation 666.		30



PROJECT NO. J304

DRAWING NO. 5

TROW SODERMAN AND ASSOCIATES

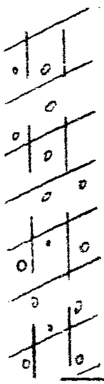
SITE INVESTIGATIONS AND SOIL MECHANICS CONSULTATION

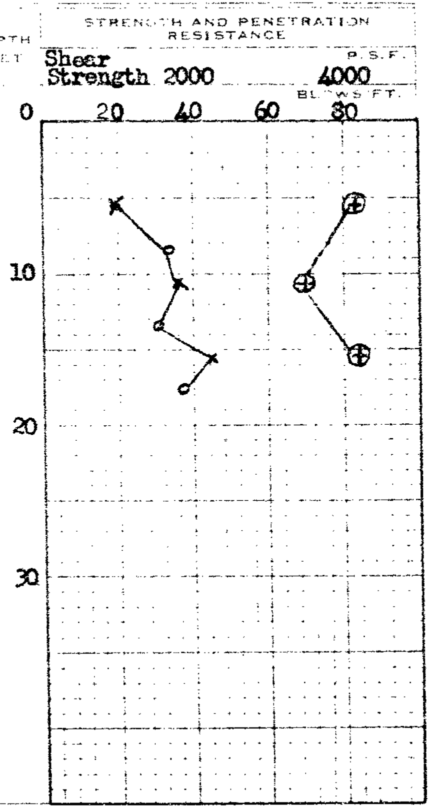
LEGEND
- 2" DIA. SPLIT TUBE
- 2" SHELBY TUBE
- 2" SPLIT TUBE
- 2" DIA. CONE
- CASING
- 2" SHELBY
- 1/2 UNCONFINED COMPRESSION (Qu) ⊕
- VANE TEST (C) AND SENSITIVITY (S) $+^S$
- NATURAL MOISTURE AND LIQUIDITY INDEX X^{LI}
- LIQUID LIMIT
- PLASTIC LIMIT

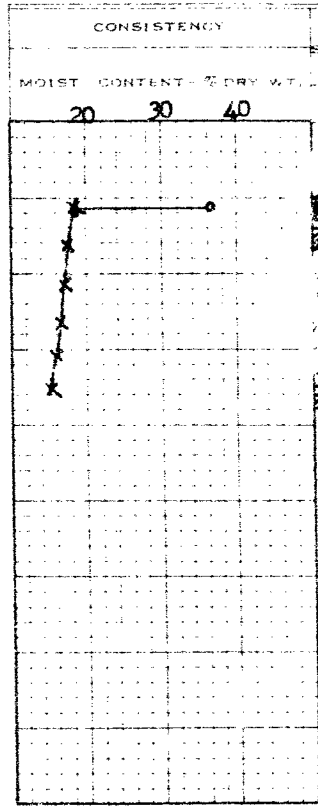
PROJECT County Rd.Bridge, Black Creek East,
LOCATION Enniskillen Twp. Lot 30
HOLE LOCATION See Dwg. 1
HOLE ELEVATION AND DATUM 670.6

BOREHOLE NO. 4
FIELD SUPERVISOR W.T.
DRILLER E.A.
PREP. W.T.

SAMPLE	DESCRIPTION	ELEV. FEET	DEPTH FEET	STRENGTH AND PENETRATION RESISTANCE	CONSISTENCY	SAMPLE	NATURAL UNIT WT. P.C.F.
	Ground surface.	670.6	0				
	Glacial Till. Very stiff grey silty clay with small pebbles.					TW1	
						SS1A	
			10			TW2	133.0
						SS2A	
						TW3	137.0
						SS3A	
			20				
	End of bore.	646					
			30				







Notes: Sampling terminated at 19 ft. AX casing driven ahead with great difficulty to 24½ ft. in very stiff adhesive clay till.

Stress Strain Curves for Unconfined Compression Tests on Samples from Holes 2 and 4

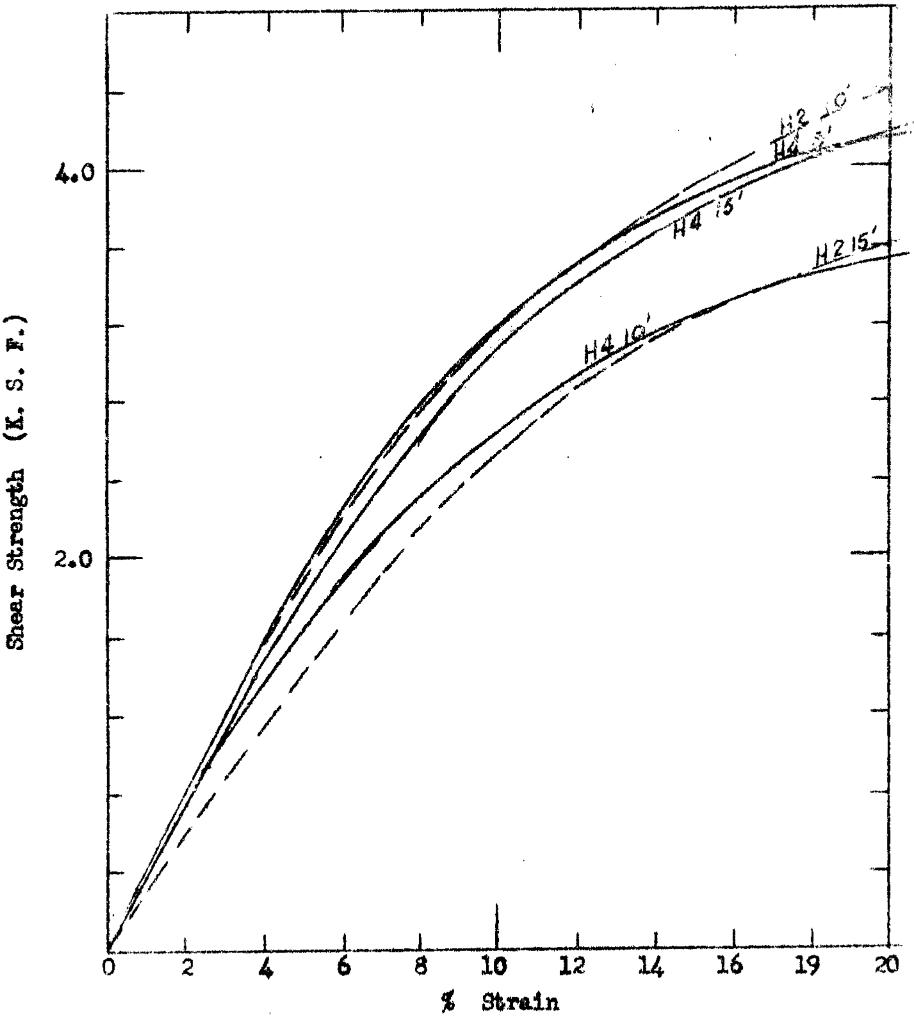


TABLE No. 1

SUMMARY OF LABORATORY TEST MEASUREMENTS

Elev. Ft.	Shear Strength (psf)*		Consistency % dry wt.						Natural Unit Weight pcf	
			W_n				L.L.	P.L.		
	Hole 2	Hole 4	Hole 1	Hole 2	Hole 3	Hole 4			Hole 2	Hole 4
670				16.6						
669			19.6							
668										
667										
666										
665	4400			17.5			31.4	16.2(H2)	137.5	
664		4150	15.6			18.2	36.3	18.2(H4)		137.5
663					16.5					
662				17.2						
661						17.3				
660	3550			17.3					138.0	
659		3500	17.6			17.2				133.0
658					17.5					
657				16.3						
656						16.2				
655				16.6						
654		4200	16.3			16.0				137.0
653					14.9					
652										
651						15.6				
650				13.4						
649			15.4							
648					16.0					
647										
646										
645										
644										
643					15.6					

* $\frac{1}{2}$ unconfined compression
W_n = natural moisture content
L.L.= liquid limit
P.L.= plastic limit.

TABLE No. 2

View of Bridge Looking North East

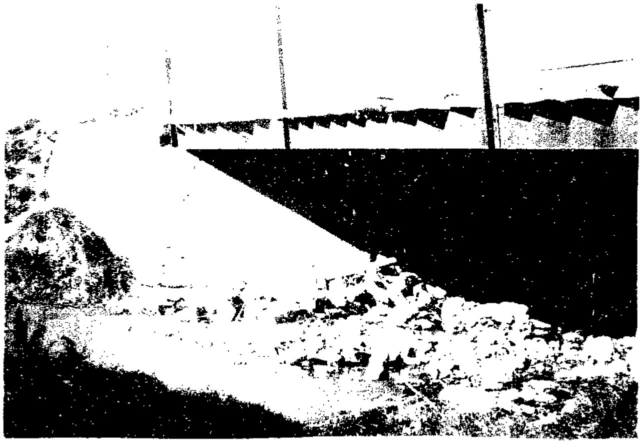
View of West Abutment
From Position Just South of Hole 3

PHOTOS ARE IN REVERSED ORDER

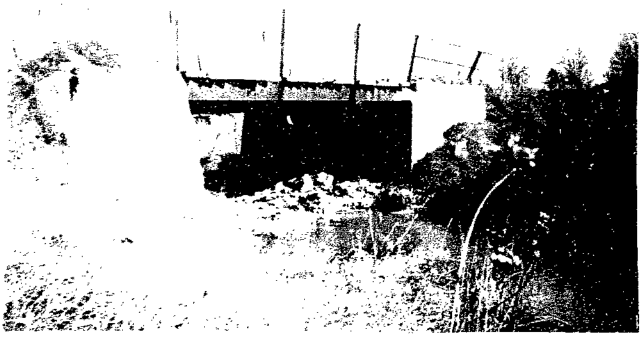
W. BKH

FROM SODERMAN AND ASSOCIATES

TABLE No. 2



View of Bridge Looking North East



View of West Abutment
From Position Just South of Hole 3