



ONTARIO

DEPARTMENT OF HIGHWAYS

Memo to	<u>Mr. A. Stermac,</u>	Date	<u>May 31, 1962.</u>
	<u>Principal Foundations Engineer</u>		<u>Structure Site #15-166</u>
	<u>D.H.O., Room 107, Lab. Bldg.,</u>	Subject	<u>County of Lambton</u>
	<u>DOWNSVIEW, Ontario.</u>		<u>Bridge over Hardy Creek</u>
From	<u>G.C.E. Burkhardt</u>		<u>On Brooke - Metcalfe T.L.</u>
			<u>Lot 29, Con. XI - Our File</u>
			<u>#BA 1412</u>

We are enclosing herewith one copy of the Foundation Report, by Dominion Soil Investigation Ltd., and one copy of the Final Plans for your comments.

We intend to approve the Plans before June 15th, 1962 and would appreciate it very much if we could have your comments prior to this date.

Since we have not enough copies of the plans we would like to have the copy back when we are sending to you to-day.

GCEB/bm

Drawing returned June 1/62
G.C.E. Burkhardt
G. C. E. Burkhardt,
for K. L. Kleinsteinber,
Municipal Bridge Liaison Eng.

Received June 1/1962 rff

No comment rff

Mo

54 1412

MESSRS. J.A. MONTEITH ASSOCIATES LIMITED
P.O. Box 579
PETROLIA ONTARIO

Report on
SOIL INVESTIGATION
for
LAMBTON COUNTY ROAD BRIDGE
CONTRACT NO. 12-62

62-5-27619

by
DOMINION SOIL INVESTIGATION LIMITED
363 Queens Avenue
LONDON ONTARIO

Reference No. 2-3-L3
March 1962

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INTRODUCTION

In accordance with a letter of authorization dated March 13th, 1962 from Mr. G.W. Ingram, a soil investigation has been made at a site on the Lambton-Middlesex County Line where a single-span bridge carries the road across Hardy Creek. The present bridge is to be replaced by a new structure of similar span and greater width.

The purpose of this investigation was to reveal the subsurface conditions and to determine the necessary soil properties for the design and construction of foundations. It was indicated that bedrock might be found at a depth of 25 feet in which case it should be located and proved, but in practice a depth of 50 feet was reached without encountering rock.

In evaluating the load-bearing characteristics of the soil we have been asked to consider a rigid-frame structure with footings 5 feet wide and a gross loading of 5000 p.s.f., and a freely supported deck on footings 10 feet wide with a gross loading of 2500 p.s.f.

I DESCRIPTION OF SITE AND GEOLOGY

The site lies in the Ekfrid Clay Plain which covers most of Ekfrid and Metcalfe Townships. The surface of the region is generally flat with occasional gullies cut by such streams as the Hardy Creek, which is a tributary of the Sydenham River. The existing bridge is situated on rising ground on the south side of the shallow valley which has been made by this stream.

II FIELD WORK

Field work was carried out during the period 16th to 19th March 1962 and consisted of 2 boreholes at the locations shown on enclosure 1. The holes were wash-bored and lined with Bx casing. A dynamic cone penetration test was made adjacent to borehole 2 only. Two attempts were made to complete such a test in the vicinity of borehole 1, but in each case the cone was deflected by particles of large diameter in the road bed, and thereafter the test was abandoned.

Standard Penetration tests were made at frequent intervals using a 2-inch O.D. split spoon. A constant driving energy was employed in the Standard Penetration and dynamic cone tests using a 140-pound hammer dropping 30 inches. The former test provided disturbed samples of the strata and the latter a continuous record of soil density.

Undisturbed samples were recovered in 2-inch diameter thin-walled Shelby tubes, and insitu vane shear tests were performed using a 4-bladed vane 2 inches in diameter and 5 inches in length. In this latter test, both the insitu and remoulded torques were determined, giving a measure of the sensitivity of the soil. Values of sensitivity between 1.5 and 3.0 were recorded.

In borehole 1 a hard till stratum was encountered at a depth of 39 feet and the hole was continued to 50 feet without encountering bedrock. Borehole 2 was terminated at a depth of 39 feet after a sample had been recovered from the surface of the till.

The results of the field tests are recorded on data sheets comprising enclosures 2 and 3. Elevations have been referred to the level of the top of the deck at the centre of the existing bridge which has been taken as El. 32.0 feet.

III SUBSURFACE CONDITIONS

A subsurface profile is shown on enclosure 1. The first 11 to 14 feet of soil is a stiff to very stiff brown, sandy, silty clay till containing traces of organics throughout its depth. This material is probably the original overburden which has been used as backfill during the construction of the present bridge.

In borehole 1 only a 3-foot layer of stiff blue-grey clay was encountered below the upper till layer. Traces of organics were found throughout this layer whose colour and presumably origin are quite different to the clay deposit which lies below it. Also in borehole 1 only, a 2-foot thick deposit of fine to medium, grey-brown wet sand was encountered below the blue clay.

Below El. 14.7 in borehole 1 and El. 19.1 in borehole 2, a bed of stiff to very stiff grey silty clay extends for a depth of approximately 24 feet. Occasional horizontal lenses of silt a few millimetres in thickness were observed, and the material contains traces of small rounded gravel particles generally less than $\frac{1}{4}$ inch diameter. This is the stratum in which it is proposed to locate the footings for the new structure, and samples have been the subject of a laboratory testing program. The physical properties of the material are described in detail in section IV.

Finally the boreholes were terminated in a hard, gravelly clay till stratum of irregular composition. From a visual inspection of the samples the gravel content is as high as 25% with particles up to 2 inches in diameter. Seams of wet, coarse sand several inches thick were also encountered within the clay matrix.

The bed of the creek was located as accurately as possible in the prevailing conditions of melting ice, and is assumed to be at El. 22.0 feet at mid-stream.

IV LABORATORY WORK

The results of tests to determine moisture content, Atterberg limits, and unconfined compressive strength on samples from the grey silty clay stratum are recorded on enclosures 2 and 3. The Atterberg limits show that the soil is a clay of low to intermediate plasticity. The plasticity index ranges from 15 to 22% and liquidity index from 0.25 to 0.37. Generally the natural moisture content lies between 20 and 26%.

The unconfined compression tests gave values for the shear strength (cohesion) of 2140, 2170, 1030 and 2450 p.s.f. (The cohesion is taken as one half of the unconfined compressive strength.) Taking these figures together with the insitu shear strength values ranging from 3000 to 5250 p.s.f. in the vane shear tests, a cohesion value of 2500 p.s.f. has been assumed for the purpose of evaluating the ultimate bearing capacity of the soil.

A consolidation test has been performed on sample 4 from borehole 2 to provide data for settlement calculations. The test results are recorded on enclosure 4.

A summary of the test data appears on enclosure 5.

V

BEARING CAPACITY AND SETTLEMENT

It is proposed that footings should be located at least one foot below the surface of the grey silty clay stratum and there should also be an allowance for scour of about 6 feet from the bed of the creek to the bottom of the footings. These conditions fix the maximum levels of the footings at Els. 13.7 and 16.0 near boreholes 1 and 2 respectively. There may be no structural disadvantage in locating the footings at different elevations, but it is conceivable that the sand stratum discovered in borehole 1 may extend to cover at least part of the area occupied by the south abutment, although the sand was not encountered at borehole 2. For the purpose of this analysis it will be assumed that the footings for both abutments will be located at El. 13.7.

The ultimate bearing capacity q_u of footings with dimensions of 5 feet x 30 feet and 10 feet x 30 feet has been calculated according to Meyerhof, assuming a value of 2500 p.s.f. for the cohesion of the clay. The proposed maximum allowable soil pressures q_a are obtained by applying a factor of safety of 3 to the ultimate figures. The results are as follows:

Dimensions of footing (feet)	Ultimate pressure q_u (p.s.f.)	Allowable pressure q_a (p.s.f.)
5 x 30	18950	6300
10 x 30	17600	5900

The figures in the last column are gross pressures, i.e. they include both the weight of the structure and overburden.

The consolidation settlement has been calculated for footings 5 feet x 30 feet and 10 feet x 30 feet loaded to 5000 and 2500 p.s.f. respectively. The distribution of vertical stress below the "characteristic point" (as defined by Kany) has been determined by Steinbrenner's method, and the theoretical oedometer settlements obtained from the results of the consolidation test. The clay has an overconsolidation ratio of between 3 and 4 indicating a pore pressure coefficient "A" of approximately 0.25. The appropriate correction factor applicable to the oedometer settlements to allow for the preconsolidation effect is then, according to Skempton, in the range 0.55 to 0.60. The resulting calculated settlements, and time for 50% and 90% consolidation are:

Dimensions of footing (feet)	Loading (p.s.f.)	Settlement (inches)	Time (days)	
			50%	90%
5 x 30	5000	1.5	309	1315
10 x 30	2500	1.2	206	875

VI

CONSTRUCTION

Surface water can be diverted by a temporary earth coffer dam placed upstream of the excavation. The valley is broad enough to allow for this and the clayey soil in the area is suitable material.

If the sand layer at borehole 2 proves to be a continuous stratum rather than an isolated pocket, it will be necessary to seal the excavation with sheet piles to prevent the flow of both water and sand. Whether such measures will be necessary at the south abutment, where no sand was encountered in the borehole, can only be determined at the time of excavation, and depends on the extent of the sand stratum.

Some seepage should be expected from the upper layer of recompact clay till if the water table is high at the time of construction. The volume, however, will be small and this alone can be treated by pumping from sumps dug below the footing grade.

A layer of lean concrete should be spread on the grade as soon as it has been exposed and examined, in order to avoid disturbance before the footings are cast.

VII SUMMARY

1. Footings should be located at El. 13.7 feet in a layer of stiff silty clay 24 feet thick whose surface was encountered at depths of 11 and 14 feet below ground surface. Above this stratum the soil is cohesive and relatively impervious except for a 2 foot layer of wet sand found in one borehole only. Below the silty clay at depths approaching 40 feet, a hard gravelly clay till was encountered and explored to a depth of 50 feet from surface.
2. A programme of laboratory tests has been carried out to determine the physical properties of the silty clay stratum.
3. The ultimate bearing capacity of footings 5 and 10 feet wide has been determined. The soil provides an adequate factor of safety for the intended loading.
4. The calculated consolidation settlements of footings 5 feet and 10 feet wide under the proposed loading are 1.5 and 1.2 inches respectively.
5. The only construction problem will be the sealing of the sand deposit found in borehole 1. If this proves to be a continuous water-bearing stratum it will be necessary to isolate the excavation with sheet piles driven into the clay. This condition was not encountered in borehole 2 near the south abutment, but allowance should also be made for sheet piling at this location in the event that it is found necessary during excavation.

VIII REFERENCES

1. The Physiography of Southern Ontario by L.J. Chapman and D.F. Putman of the Ontario Research Foundation - University of Toronto Press 1931.
2. Procedures for Testing Soils, ASTM, April 1958. pp. 186 to 196 (Unified Soil Classification System - by A.A. Wagner).
3. Proceedings of the 4th International Conference on Soil Mechanics and Foundation Engineering (Research on Determining the Density of Sands by Spoon Penetration Testing - by H.J. Gibbs and W.G. Holtz of the United States Bureau of Reclamation.)

4. Terzaghi and Peck: Soil Mechanics in Engineering Practice. John Wiley and Sons, New York 1948.
5. Karl Terzaghi: Theoretical Soil Mechanics, John Wiley and Sons, New York, 1943.
6. The Ultimate Bearing Capacity of Foundations by G.G. Meyerhof Geotechnique, Vol. II, 1950 and 1951.
7. A Contribution To The Settlement Analysis of Foundations on Clay by A.W. Skempton and L. Bjerrum - Geotechnique VII. (1957) and Amendment Thereto by A.M. Muir Wood (Correspondence, Geotechnique Vol. IX.)



DOMINION SOIL INVESTIGATION LIMITED

James Park

James Park, M.Sc., P.Eng.

GEOTECHNICAL DATA SHEET FOR BOREHOLE ... 1 ...

OUR REFERENCE NO. 2-3-L3

CLIENT: J.A. Monteith Associates Limited

METHOD OF BORING: Wash boring

ENCLOSURE NO. 2

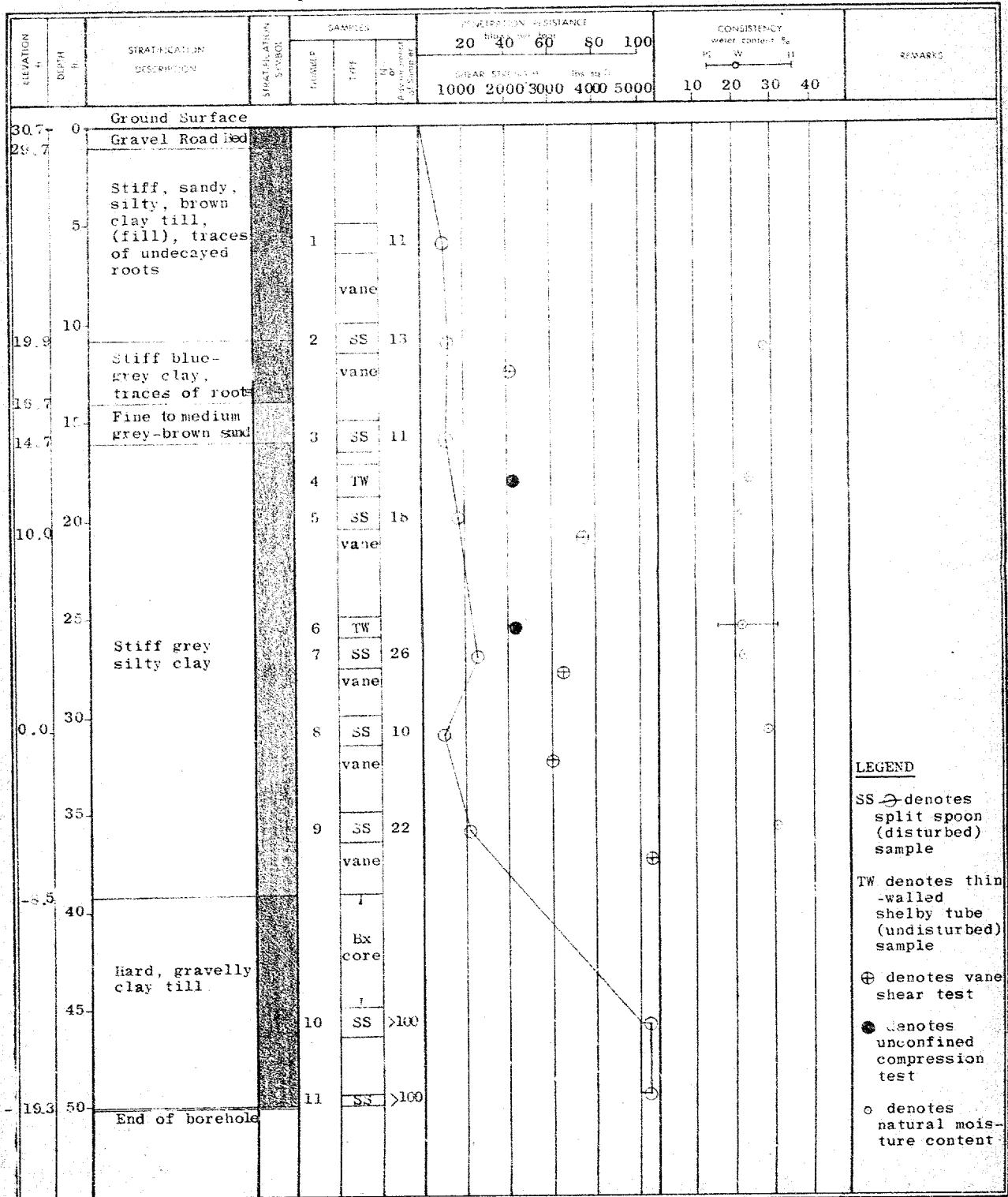
PROJECT: County Road Bridge

DIAMETER OF BOREHOLE: Bx

LOCATION: Lambton-Middlesex County Line at Hardy Creek

DATE: 16/17 - 3 - 62

DATUM (ELEVATION): Centre top of deck - 32.0'



LEGEND

SS ⊕ denotes split spoon (disturbed) sample

TW denotes thin-walled shelby tube (undisturbed) sample

⊕ denotes vane shear test

● denotes unconfined compression test

○ denotes natural moisture content

GEOTECHNICAL DATA SHEET FOR BOREHOLE . . 2 . . .

YOUR REFERENCE NO. 2-3-L3

CLIENT J.A. Monteith Associates Limited

PROJECT County Road Bridge

LOCATION Lambton-Middlesex County Line at Hardy Creek

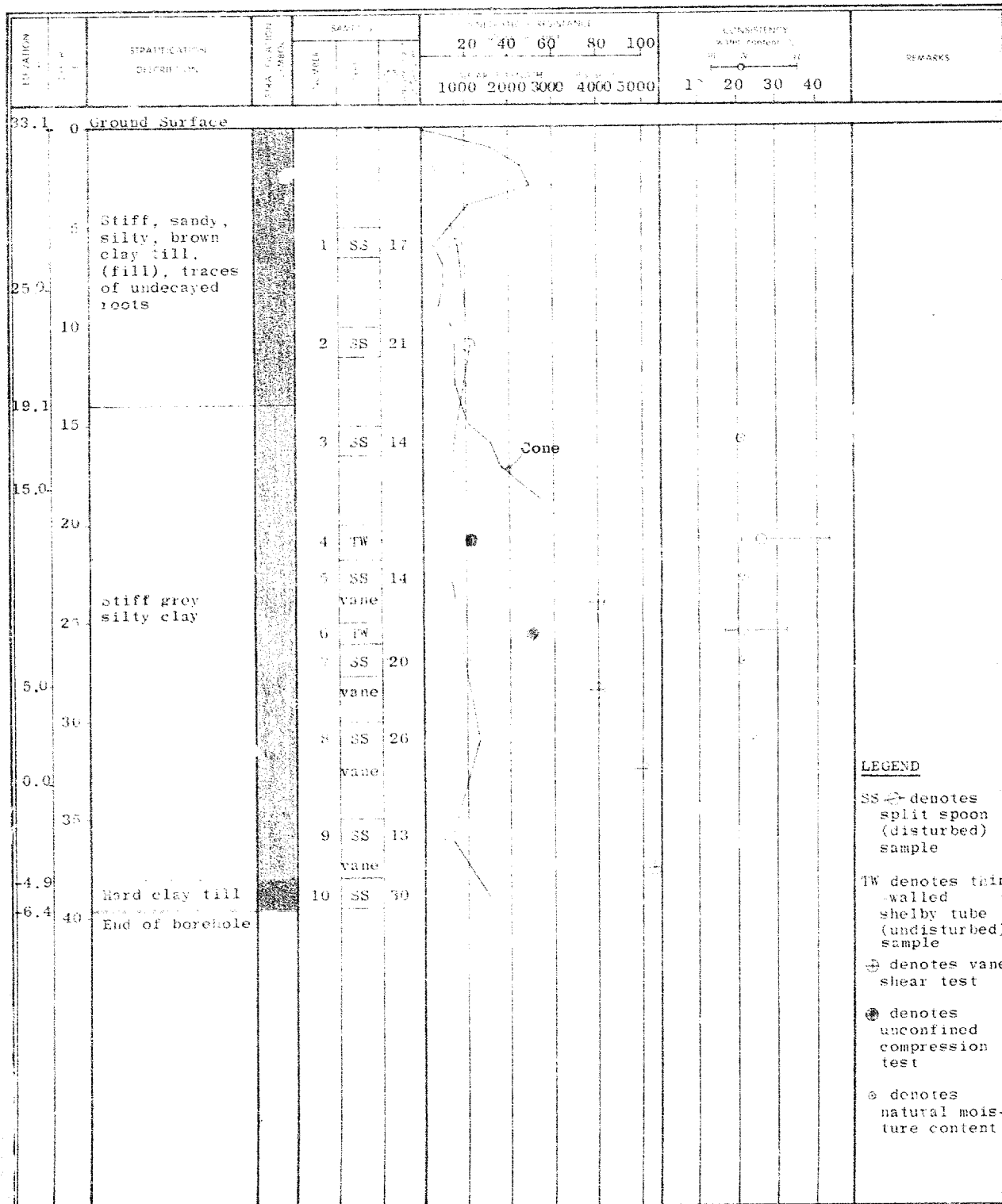
DATUM ELEVATION Centre top of deck - 32.0'

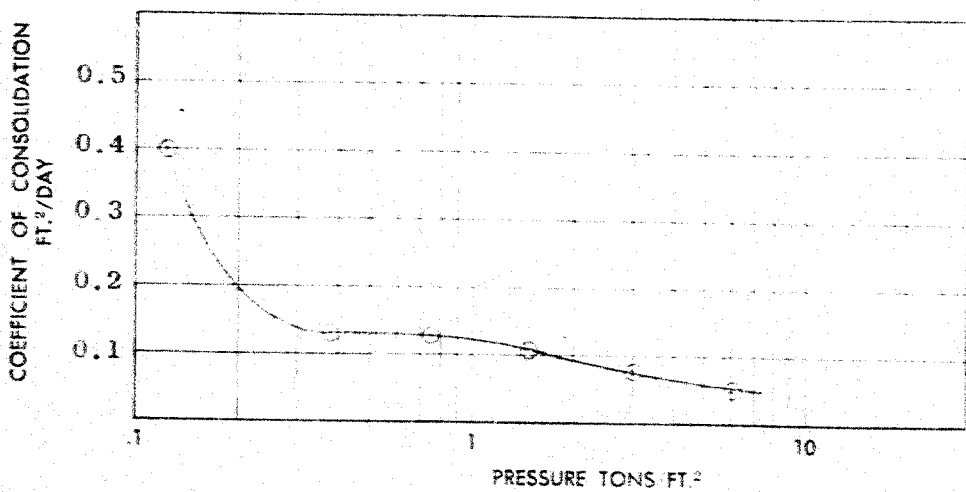
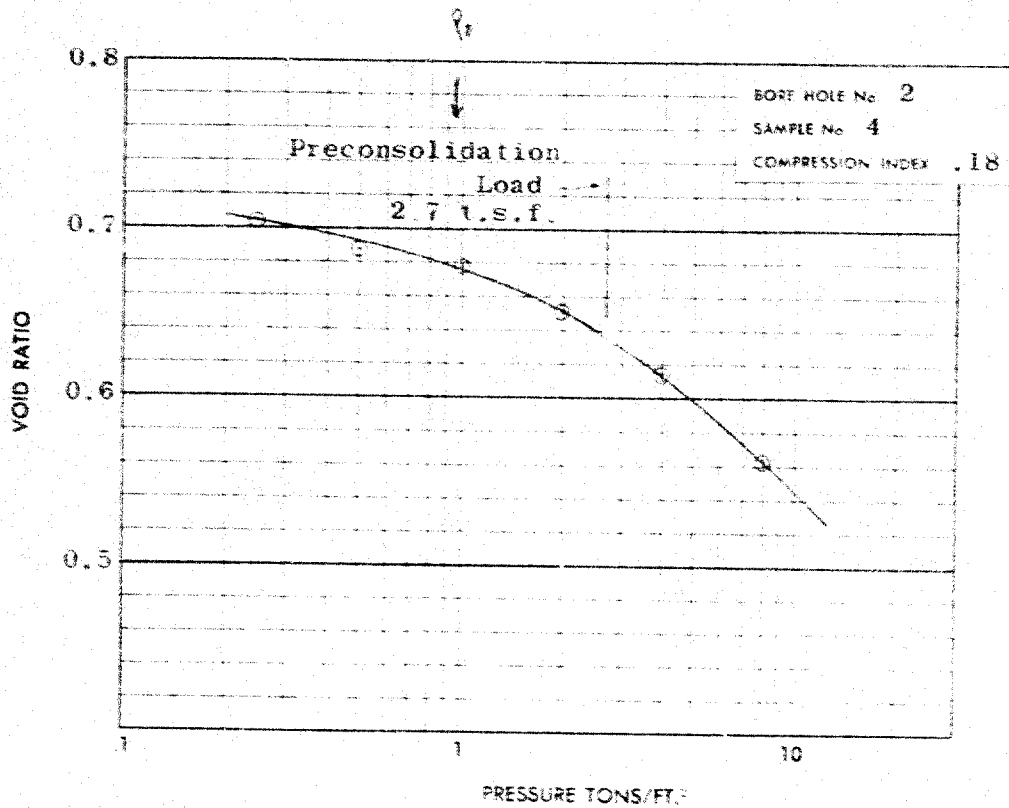
METHOD OF BORING Wash boring

DIAMETER OF BOREHOLE Bx

DATE 17/19-3 62

ENCLOSURE NO. 3



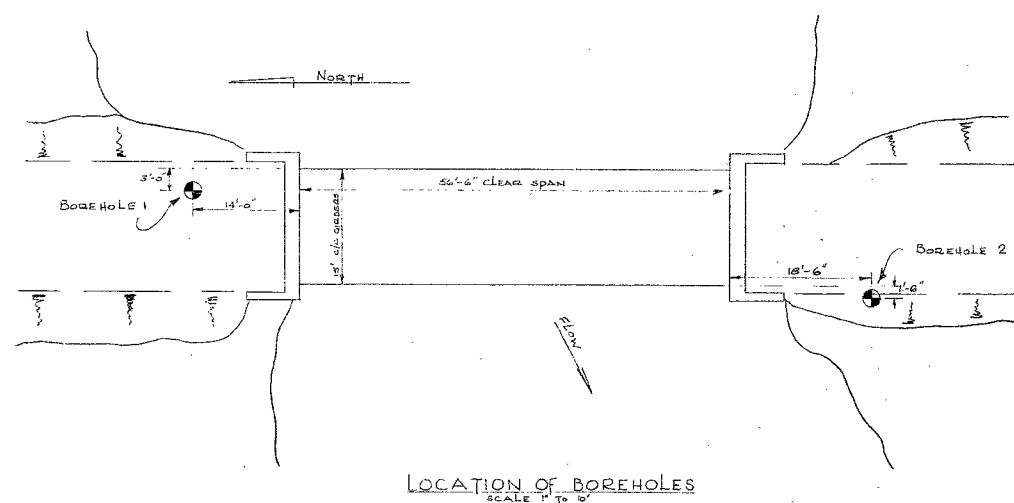
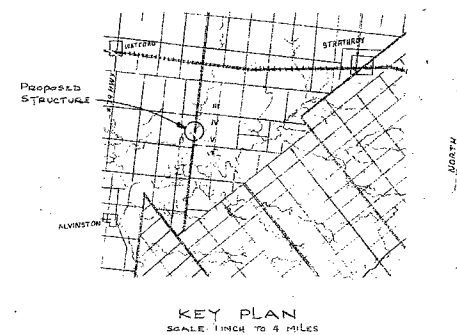
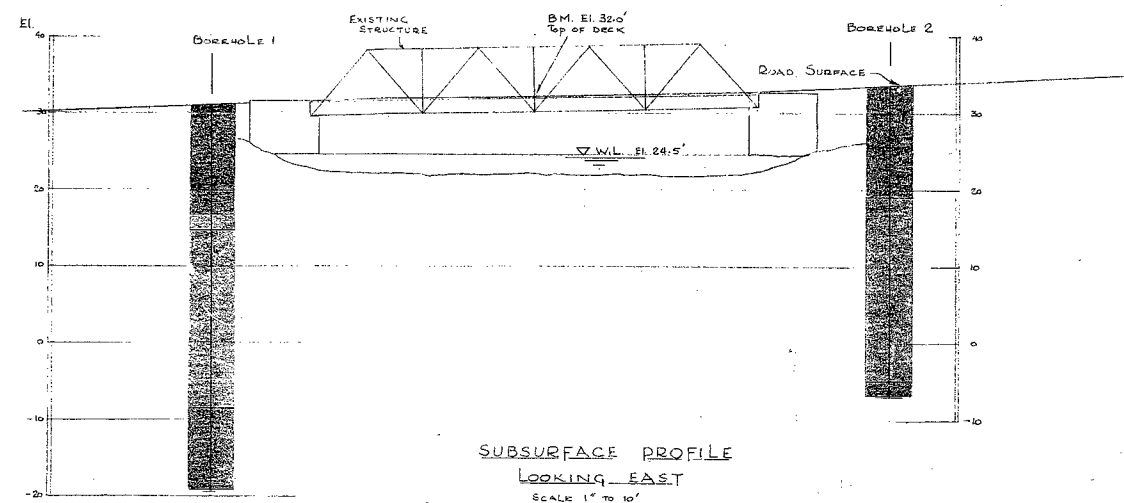
Domiaion Soil Investigation Ltd.**CONSOLIDATION TEST**

SUMMARY OF LABORATORY TEST DATA

Borehole No.	1	1	2	2
Sample No.	4	6	4	6
Liquid limit (%)	-	30.8	42.9	32.1
Plastic limit (%)	-	16.4	20.7	16.4
Plasticity index (%)	-	14.4	22.2	15.7
Liquidity index	-	0.37	0.25	0.29
Natural moisture (%)	23.8	21.8	26.4	20.9
Void ratio	0.66	0.60	0.71	0.58
Bulk density (p.c.f.)	128	132	119	131
Unconfined compressive strength (p.s.f.)	4280	4340	2060	4890
Compression index	-	-	0.18	-

Borehole	Sample	Natural Moisture (%)
1	2	28.2
	5	21.5
	7	22.0
	8	27.8
	9	30.8
2	3	21.2
	5	21.9
	7	20.6
	8	23.5
	9	30.3

62-F-275M
HARDY CREEK
ON BROOKE-
METCALFE TL.
LOT 29, CON. 11



LEGEND

- SANDY, SILTY, BROWN CLAY TILL (FILL)
TRACES OF UNDECAYED ROOTS
- BLUE-GRAY CLAY, TRACE OF ORGANICS
- FINE TO MEDIUM GRAY-BROWN SAND
- STIFF GRAY SILTY CLAY
- HARD GRAVELLY CLAY TILL

ENCLOSURE No 1	J. A. MONTEITH ASSOCIATES LIMITED PETROLIA ONTARIO
REF. 2-3-13 MARCH 1962	SOIL INVESTIGATION FOR LAMBTON COUNTY BRIDGE CONTRACT No. 12-62
DRAWN BY M.C.	Dominion SOIL INVESTIGATION LIMITED LONDON 363 QUEENS AVENUE ONTARIO
CHECKED BY J.D.	