#66 - F - 265 M

CTY. RD. #2, LOT 10

BRIDGE

CONS. 11 / 12

SOMBRA TWP.

3A 2290
SITE 14-329

COUNTY OF LAMBTON

c/o NISBET-LETHAN LIMITED

CONSULTING ENGINEERS

206 WATER STREET

SARNIA, ONTARIO

REPORT ON

SOIL INVESTIGATION AND FOUNDATIONS

FOR

PROPOSED BRIDGE

ON

COUNTY ROAD NO. 2

LOT 10, CONCESSIONS 11 AND 12

OF SOMBRA TOWNSHIP

SUBMITTED BY

DOMINION SOIL INVESTIGATION LIMITED
77 CROCKFORD BOULEVARD
SCARBOROUGH ONTARIO

REFERENCE:
6-1-L10
FEBRUARY - 1966

# C O N T E N T S



# E N C L O S U R E S

## INTRODUCTION

The soil investigation described in this report was authorized by Messrs. Nisbet-Lethan Limited, Consulting Engineers when requesting a subsurface exploration for a proposed bridge in Sombra Township where County Road No. 2 crosses Indian Creek.

At the present time, a 14 foot wide concrete culvert serves as a connecting link between the two shores. However, because of its inadequate size, and the need to regulate the flow of the creek in this area, it is planned to replace it with a new and longer structure.

To investigate the subsurface conditions, two boreholes were requested by the client, each located near the proposed abutments. The results of the borings, together with the recommendations for foundation design are presented in the following paragraphs.

## PROCEDURES

The boreholes, the locations of which in reference to the existing structure are shown on Enclosure No. 2, were put down on January 26th and 27th, 1966. The holes were advanced by washboring techniques using a standard diamond drill machine. During the field work, the subsoil was penetrated for a maximum depth of 26½ feet to which depth the overburden was sampled at 2½ or 5 foot intervals. Because of the hard consistency of the subsoil, only disturbed soil samples were recovered by a standard 2" O.D. split-spoon sampler. When obtaining samples, Standard

Penetration tests were also performed with the purpose of determining the consistency of the subsoil. The recovered soil samples were shipped in air-tight jars to the soil laboratories of Dominion Soil Investigation Limited for classification and testing. Details of the borings are shown on the individual geotechnical data sheets of the boreholes and results of the laboratory tests are tabulated on Enclosure No. 5.

Ground surface elevations at the locations of the boreholes and other pertinent points were obtained by levelling, using Bench Mark No. 21 as datum elevation. This bench mark was supplied by the Consulting Engineers and was described as a nail in the south face of a 3 ft. diameter elm tree, 3 feet above ground left of Station 233 + 68. The elevation was given as 585.74 feet and is believed to be referred to the geodetic datum.

DESCRIPTION OF SITE, GEOLOGY AND SOIL CONDITIONS

The site is located in Lot 10 of Concessions 11 and 12 of Sombra Township. The entire area is one of low relief with an average ground surface elevation of 600 feet. Because of the flat topography and predominantly clayey subsoils, the drainage of the area is poor.

During the Pleistocene Epoch, Ontario was completely covered by at least four distinct continental ice sheets. The last of these glacial stages known as the Wisconsin, is believed to have completely denuded the Paleozoic bedrock in the southwestern Ontario peninsula. The soil types now present in this area were deposited during this glacial period and the surface features now evident reflect the influence of interstitial post glacial lakes. In general, the soil types occurring in the region exhibit a marked similarity in composition and can be classified as clayey silts of low to medium plasticity. The absence of large size particles typical of glacial deposits found elsewhere may be explained by the relatively soft nature of the underlying bedrock. The thickness of the overburden shows little variation and the bedrock is generally encountered at a depth of 100 to 120 feet. The limestone and shale bedrock was formed during the Devonian period of the Paleozoic era.

The investigation has indicated that in the area of the proposed structure, the site is underlain by the typical clay till described above. From below the ground surface (Elevation 585 ± ft.) to about Elevation 570, the till has a brown-grey mottled colour. Below Elevation 570 ft., the colour changes to a uniform grey. The till has a uniform fine texture in which numerous fine to coarse gravel particles are embedded. The presence of small sand pockets and lenses are also indicated. Typical grain-size distribution curve of the material is shown on Enclosure No. 6. This curve indicates that the till consists of about 20% sand, 40% silt and about 40% clay.

The till exhibits considerable cohesion and plasticity. The plastic properties of the clay were determined by Atterberg tests giving the following results:

| | |
|---|---|
| Liquid Limit | 42% to 48% |
| Plastic Limit | 20% to 23% |
| Plasticity Index | 22% to 26% |
| Natural Moisture Content | 18% to 25% |
| Liquidity Index | 0.1 to 0.2 |

On the basis of these limits, the material is classified in Cassagrande's classification system as a clay of medium plasticity.

The consistency of the till can be only inferred from the Liquidity Indices and the Standard Penetration tests. The "N" values measured in the Standard Penetration tests range between 15 and 62 blows per foot indicating a range of consistency between very stiff and very hard.On the average, the "N" values are over 30 blows per foot corresponding to a hard consistency. The Liquidity Indices, however, which relate the Natural Moisture Content to the Consistency Limits, do not bear out these results. From the Liquidity Indices, which are generally of the order of 0.1 to 0.2, only a very stiff consistency can be inferred. Since it is generally recognized that the Standard Penetration tests have only a limited application in case of cohesive soils and could occasionally lead to misinterpretation of the results, in the present case it will be assumed that the till has very stiff consistency with an average shear strength probably not greater than 3,000 lbs. per square foot.

Because of the low permeability of the subsoil, the equilibrium position of the ground water in the boreholes could not be established during the limited time of the field work, but it is believed that it will be at or close to the water level in the nearby creek. This, at the time of the investigation, was measured at Elevation 580.3 feet.

## DISCUSSION

The actual type, size and nature of the proposed structure is not known, but for the purpose of discussion it will be assumed that it will be a single-span structure of approximately 25 ~~60 to 70~~ feet span and that it will be of reinforced concrete construction.

The footings of the proposed structure should be carried below the maximum depth of scour which tentatively is assumed to be 5 feet. This, however, should be confirmed by hydraulic studies. Assuming that the lowest point of the creek bottom is at Elevation 579 ± ft. as measured by our field crew, the most likely foundation level will be Elevation 574 feet. Assuming 3,000 lbs. per square foot as the average undrained shear strength of the till, the ultimate bearing capacity of the subsoil is 17,000 lbs. per square foot. Thus, for a maximum design pressure of 6,000 lbs. per square foot, the factor of safety against general shear failure of the soil would be 2.85. This in the case of a soil of medium sensitivity, such as the present clay till, is considered to be adequate. Because of the somewhat lower safety factor, however, it is suggested that the maximum edge pressure under the eccentrically loaded foundations should not exceed the recommended bearing value.

The adhesion between the rough base of the foundation and the subsoil can be assumed to be 2,000 lbs. per square foot and the design should aim to secure a safety factor of not less than 1.75 against the horizontal sliding of the abutments. Because of the possibility of future scour, the passive earth resistance in front of the footings should not be included in the design.

The probable settlement of the structure was estimated on the assumption that the continuous footings will be 7 feet wide and that the modulus of compressibility of the subsoil 'K' is equal to 80 tons per square foot. Under maximum dead and live load conditions, assuming 42 kips per linear foot acting at the base of the footings, the settlement was calculated to be 2.4 inches. However, since the significant portion of the total settlement will be due to the long-term consolidation of the clayey soil, it would be more reasonable to compute the settlement for the total dead load and only a reduced portion of the live load. Assuming that only 20% of the live load is acting all the time and that the dead load constitutes about 37% of the total load, the reduced load to be considered in the settlement analysis will be about 50% of the total load. On this basis, the maximum total settlement is estimated to be 1.2 inches. Because of the relatively uniform soil conditions, the amount of differential settlement is estimated not to exceed 50% of the total value. Both these values ($S$ max. = 1.2 inches; $\Delta S$ max. = 0.6 inches) are considered to be within the tolerable limits for the structure proposed. The rate of consolidation is estimated to be slow and it is believed that 90% of the consolidation will take place over a period of more than 2 years.

## CONCLUSIONS

The subsurface exploration has revealed that the site is underlain by stiff to very stiff cohesive strata suitable to support the proposed structure on normal spread footing foundations. The recommended design pressure is 6,000 lbs. per square foot and both total and differential settlements are estimated not to exceed 1.2 and 0.6 inches respectively.

DOMINION SOIL INVESTIGATION LIMITED,

IPL/jvm

I. P. Lieszkowszky, P. Eng.,
Project Engineer.

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 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | COARSE | FINE | COARSE | MEDIUM | FINE | | | | |

Ø > 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

| GROUND WATER LEVEL | DEPTH OF CAVE-IN |
|---|---|

## 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.

SYMBOL:

DYNAMIC PENETRATION RESISTANCE to drive a 2"ø, 60° cone attached to the end of the [illegible] the ground, expressed in blows per foot

STANDARD PENETRATION RESISTANCE -N- to drive a 2" outside dia., split spoon sampler [illegible] foot into the ground, expressed in blows per foot.

EXTRA[illegible] -N- VALUE 322

The energy [illegible] penetration resistances is supplied by a 140 lb. hammer falling 30 inches

## 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 total stress |
| PI % | Plasticity index | $C_v$ | Coeff. of consolidation | $C'$ | Cohesion — in terms of effective stress |
| LI | Liquidity index | $m_v$ | Coeff. of volume compressibility | $\phi'$ | Angle of int. friction — in terms of effective stress |

## UNDRAINED SHEAR STRENGTH.

— DERIVED FROM —

TRIAXIAL / UNCONFINED COMPRESSION TEST ● ●St

LABORATORY / FIELD VANE TEST X St +St

POCKET PENETROMETER TEST ▼St

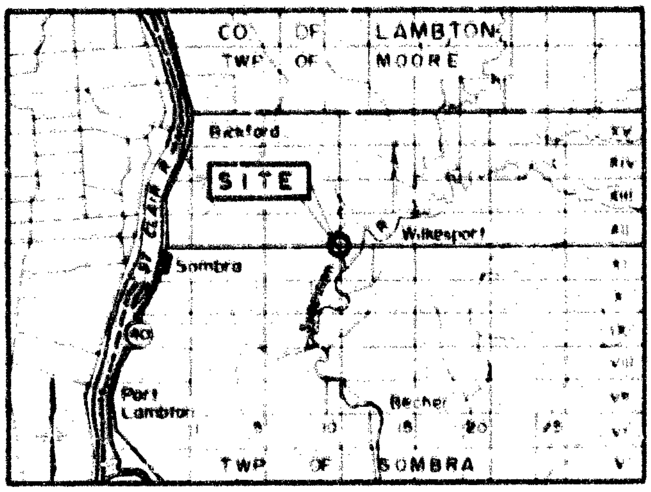
Strain at failure is represented by direction of stem: 20% 15% 5% 10%

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

## SOIL DESCRIPTION.

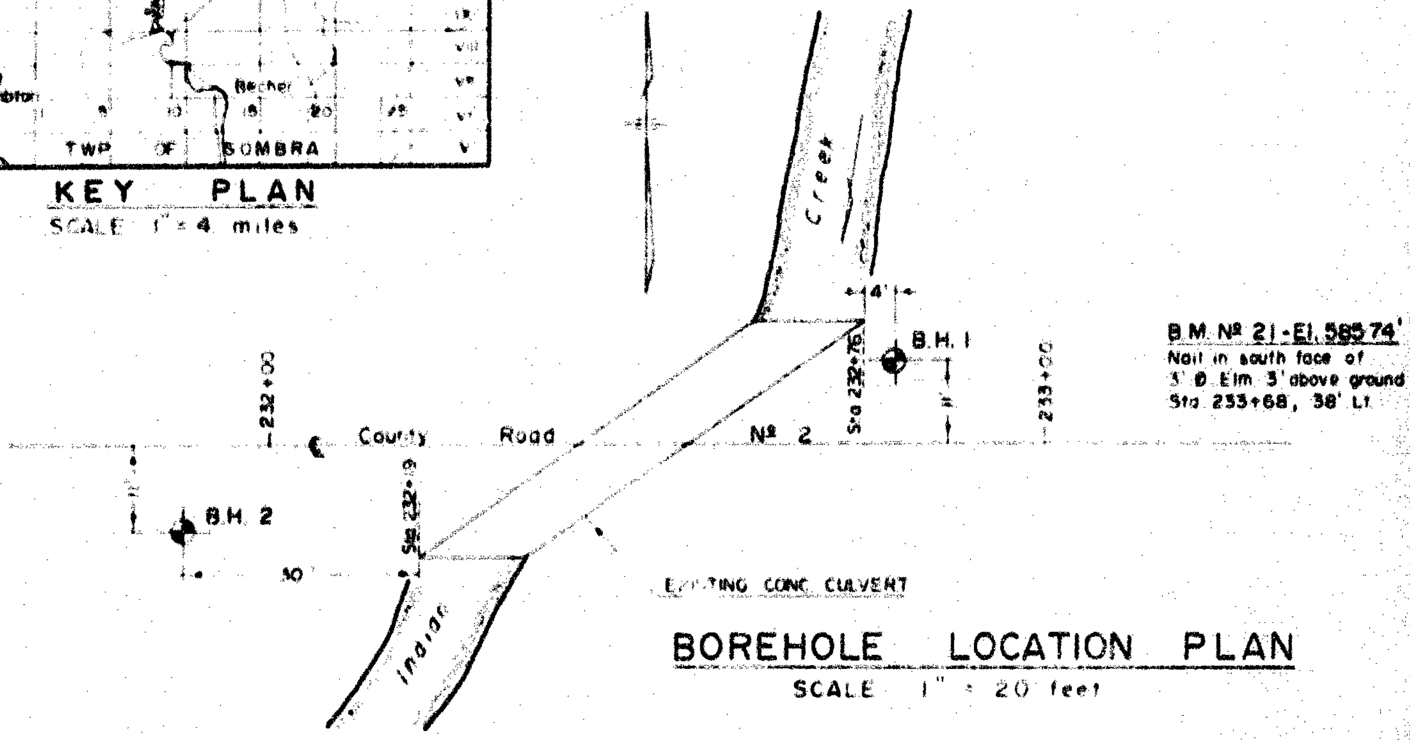
| COHESIONLESS SOILS: | RD: |
|---|---|
| Very loose | 0 - 15 % |
| Loose | 15 - 35 % |
| Compact | 35 - 65 % |
| Dense | 65 - 85 % |
| Very dense | 85 - 100 % |

| COHESIVE SOILS: | C lbs/sq.ft |
|---|---|
| Very soft | less than 250 |
| Soft | 250 - 500 |
| Firm | 500 - 1000 |
| Stiff | 1000 - 2000 |
| Very stiff | 2000 - 4000 |
| Hard | over 4000 |



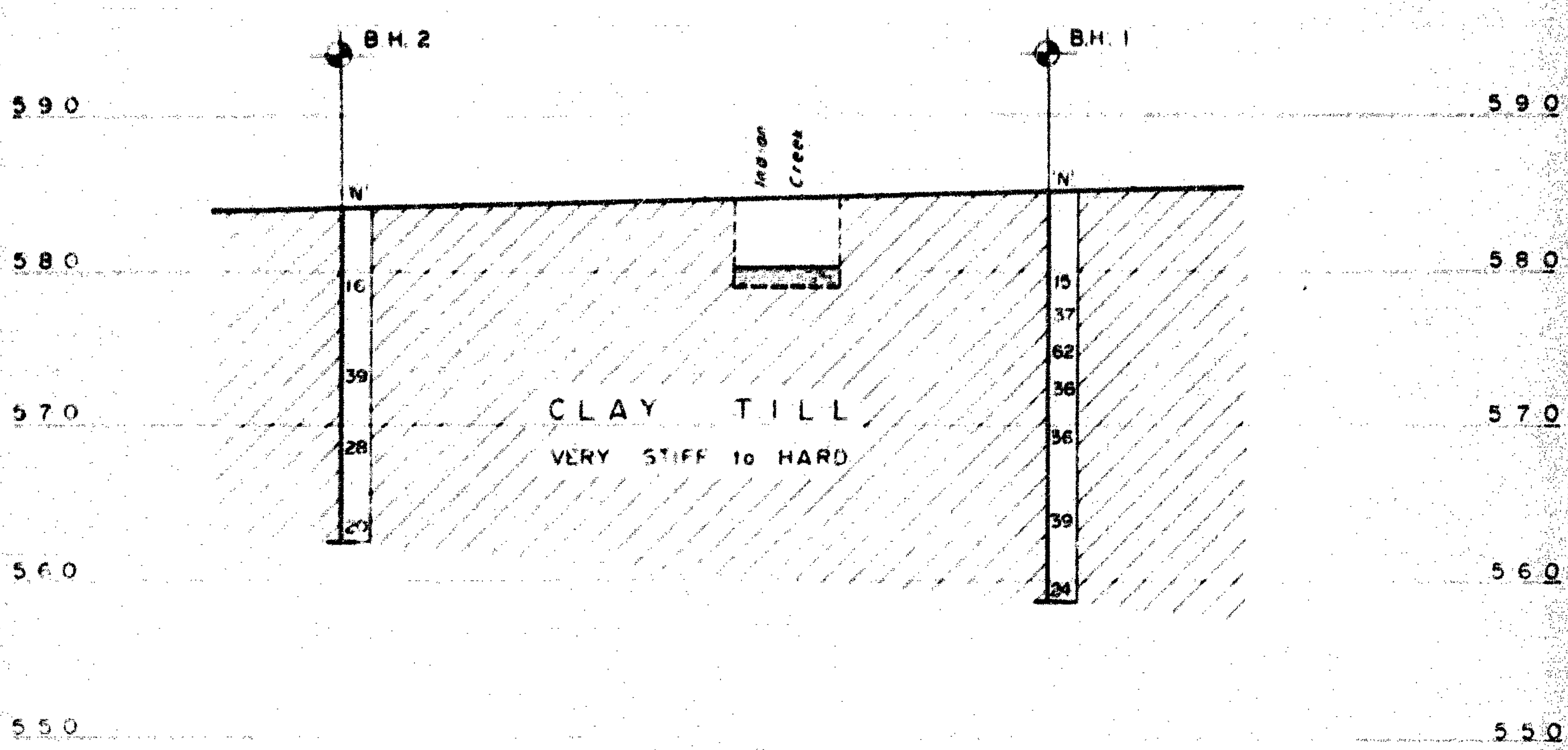

## KEY PLAN

SCALE 1" = 4 miles




## BOREHOLE LOCATION PLAN

SCALE 1" = 20 feet




## SUBSURFACE PROFILE

SCALE Horiz. 1" = 20 feet
Vert. 1" = 10 feet

DEFECTS IN NEGATIVE DUE TO CONDITION OF ORIGINAL DOCUMENT

DEFECTS IN NEGATIVE DUE TO
CONDITION OF ORIGINAL DOCUMENT

# GEOTECHNICAL DATA SHEET FOR BOREHOLE 1

OUR REFERENCE NO. 6 - 1 - L 10

CLIENT NISBET - LETHAN LTD.
PROJECT PROPOSED BRIDGE
LOCATION TWP. SUMBRA, CO RD. Nº 2
DATUM ELEVATION B.M. Nº 21 - El 585.74 ft.

METHOD OF BORING WASHBORING
DIAMETER OF BOREHOLE 2 3/8"
DATE JAN. 26, 1966

ENCLOSURE NO. 5

| ELEVATION | DEPTH | STRATIFICATION DESCRIPTION | STRATIFICATION SYMBOL | SAMPLES NUMBER | SAMPLES TYPE | N | PENETRATION RESISTANCE blows per foot 20 40 60 80 100 / SHEAR STRENGTH 1000 lbs. sq ft 1 2 3 4 5 | CONSISTENCY water content % PL W LL 10 20 30 40 | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| 585.2 | 0 | GROUND SURFACE | | | | | | | |
| | | Very Stiff to Hard CLAY TILL with small sand lenses | | | | | | | |
| 580.0 | 5 | | | 1 | S.S. | 15 | | | |
| | | | | 2 | S.S. | 37 | | | |
| 575.0 | 10 | brown / grey | | 3 | S.S. | 62 | | | GRAIN SIZE DISTR. (SEE ENCL. Nº 6) |
| | | | | 4 | S.S. | 38 | | | |
| 570.0 | 15 | | | 5 | S.S. | 36 | | | |
| 565.0 | 20 | | | 6 | S.S. | 39 | | | |
| 560.0 | 25 | | | 7 | S.S. | 24 | | | |
| | 28.5 | END OF BOREHOLE | | | | | | | |
| 555.0 | 30 | | | | | | | | |

VERTICAL SCALE: 1 IN. TO 5 FT.

DOMINION SOIL INVESTIGATION LIMITED

MADE: D.A.M. CH'D:

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# GEOTECHNICAL DATA SHEET FOR BOREHOLE 2

OUR REFERENCE NO. 6 - 1 - L 10

CLIENT NISBET - LETHAN LTD
PROJECT PROPOSED BRIDGE
LOCATION TWP OF SOMBRA, CO RD. Nº 2
DATUM ELEVATION B. M. Nº 21 - El. 585.74 ft

METHOD OF BORING WASHBORING
DIAMETER OF BOREHOLE 2 5/8"
DATE JAN 27, 1966

ENCLOSURE NO. 4

| ELEVATION ft | DEPTH ft | STRATIFICATION DESCRIPTION | SAMPLES NUMBER | TYPE | BLOWS | PENETRATION RESISTANCE blows per foot (20 40 60 80 100) / SHEAR STRENGTH 1000 lbs sq ft (1 2 3 4 5) | CONSISTENCY water content % (PL W LL) (10 20 30 40) | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 584.1 | 0 | GROUND SURFACE | | | | | | |
| 580.0 | 5 | Very Stiff CLAY TILL with small sand lenses | 1 | SS | 16 | | | |
| 575.0 | 10 | | 2 | SS | 39 | | | |
| | | brown / grey | | | | | | |
| 570.0 | 15 | | 3 | SS | 28 | | | |
| 565.0 | 20 | | 4 | SS | 20 | | | |
| | 21.9 | END OF BOREHOLE | | | | | | |
| 560.0 | 25 | | | | | | | |

VERTICAL SCALE 1 IN. TO 5 FT

DOMINION SOIL INVESTIGATION LIMITED

MADE: D. A. M. CH'D:

| SAMPLE DETAILS | | | | CONSISTENCY | | | | | UNDRAINED COMPRESSION | | UNIT WEIGHT | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BOREHOLE | SAMPLE | TYPE | AVERAGE DEPTH (FEET) | NATURAL WATER CONTENT (%) | LIQUID LIMIT (%) | PLASTIC LIMIT (%) | PLASTICITY INDEX | LIQUIDITY INDEX | SHEAR STRENGTH (P.S. FT.) | AXIAL STRAIN AT FAILURE (%) | (P.C. FT.) | |
| 1 | 1 | S.S. | 5·0 | 17·6 | | | | | | | | |
| | 2 | S.S. | 7·5 | 20·6 | | | | | | | | |
| | 3 | S.S. | 10·0 | 20·8 | 48·0 | 22·0 | 26·0 | — | | | | Grain Size Distribution (Encl. 6) |
| | 4 | S.S. | 12·5 | 22·1 | | | | | | | | |
| | 5 | S.S. | 15·0 | 21·9 | 42·0 | 20·0 | 22·0 | 0·1 | | | | |
| | 6 | S.S. | 20·0 | 22·5 | | | | | | | | |
| | 7 | S.S. | 25·0 | 24·4 | 42·0 | 20·0 | 22·0 | 0·2 | | | | |
| 2 | 3 | S.S. | 15·0 | 24·4 | 48·0 | 23·0 | 25·0 | 0·06 | | | | |
| | 4 | S.S. | 20·0 | 24·9 | | | | | | | | |

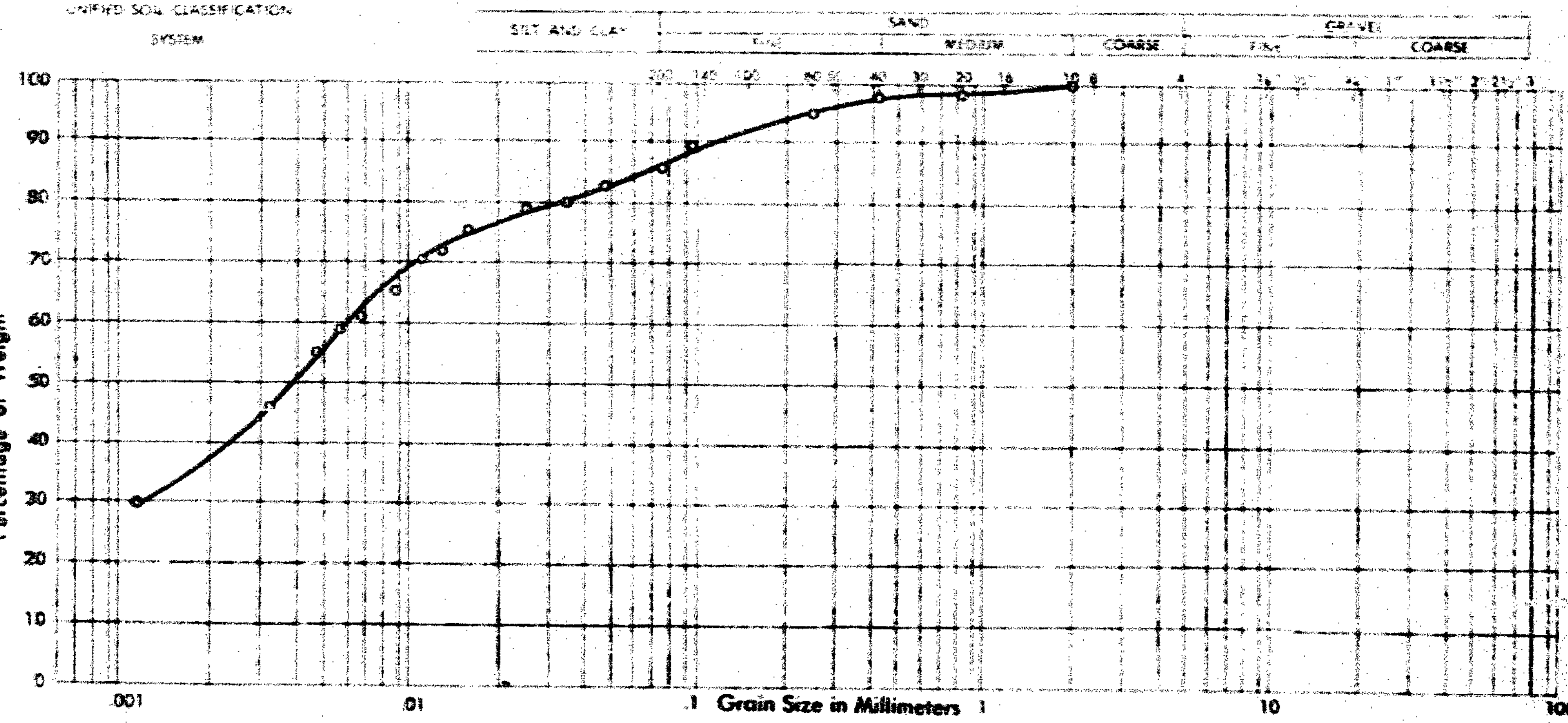
# TABLE OF LABORATORY TEST RESULTS

DEFECTS IN NEGATIVE DUE TO CONDITION OF ORIGINAL DOCUMENT

# DOMINION SOIL INVESTIGATION LIMITED

## GRAIN SIZE DISTRIBUTION

OUR REFERENCE NO. 6 - I - L10




PROJECT PROP. BRIDGE ON CO. RD. Nº 2

LOCATION SOMBRA TWP.

BOREHOLE NO. 1

SAMPLE NO. 3

DEPTH OF SAMPLE 10' - 11.5'

ELEVATION OF SAMPLE 874 ± ft.

COEFFICIENT OF UNIFORMITY

COEFFICIENT OF CURVATURE

**Classification of Sample and Group Symbol:**

CLAYEY SILT with some sand

(CLAY TILL)

CI

PLASTIC PROPERTIES

| | | |
|---|---|---|
| LIQUID LIMIT | % = | 48 |
| PLASTIC LIMIT | % = | 22 |
| PLASTICITY INDEX | % = | 26 |
| MOISTURE CONTENT | % = | 21 |
| ACTIVITY | = | |

Enclosure No. 8

DEFECTS IN NEGATIVE DUE TO CONDITION OF ORIGINAL DOCUMENT