

W.O. 70-F-210M

BOX BRIDGE,

TWP. LONDON

LOT 6 CON VI

40P3-44

| |
|-------------|
| 40P3-44 |
| GEOCREs No. |

R. C. DUNN & ASSOCIATES LIMITED

70-F-210 M

SUBSURFACE INVESTIGATION

PROPOSED BOX BRIDGE RECONSTRUCTION

LONDON TOWNSHIP MIDDLESEX COUNTY

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Golder Associates

SOIL AND FOUNDATION ENGINEERS

April 13, 1970.

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747 Hyde Park Road,
LONDON 73, Ontario.

ATTENTION: Mr. N. H. Warner, P. Eng.

RE: Subsurface Investigation
Proposed Box Bridge
Reconstruction, London
Township, Middlesex County

Dear Sirs:

This letter reports the results of a subsurface investigation carried out at the site of the proposed Box Bridge reconstruction on Concession Road VI at Lot 6 in the Township of London, County of Middlesex, Ontario. The purpose of the investigation was to establish the soil and groundwater conditions at the site and to make recommendations for foundation design and construction of the proposed bridge.

PROCEDURE

Two boreholes were put down on March 18, 1970, using a truck mounted power auger supplied and operated by P.V.K. and Sons Drilling Limited. The locations of the boreholes are shown on the site plan and stratigraphic section, Figure 1. Standard penetration tests were carried out in both boreholes and the samples obtained were brought to our London laboratory for detailed examination and representative testing. The results of the laboratory tests are shown on the Record of Borehole sheet and as Figure 2. Perforated standpipes were

installed in each borehole immediately following the completion of drilling and measurements were made three weeks later to determine the stabilized groundwater level. Details of these installations together with the observed groundwater levels are given on the Record of Borehole sheet.

The elevations given in this report are referred to a bench mark shown on a drawing of the existing structure prepared by R. C. Dunn & Associates Limited. The elevation of this point, the top of concrete of the southwest wingwall, was given as 87.08 referred to a local datum.

SUBSURFACE CONDITIONS

The detailed stratigraphy encountered in the boreholes is shown on the Record of Borehole sheet following the text of this report. Soil conditions at the site consist of about 10 feet of variable fill overlying dense sandy silt till.

The top 3 to 4 feet of fill encountered in both boreholes was found to be dense to very dense brown sand and gravel with N values as measured in the standard penetration test of between 46 and 98 blows per foot and a natural water content of about 11 per cent. Underlying the sand and gravel in borehole 1 to a depth of about 11 feet, 3 feet of loose sand and 5 feet of stiff clayey silt were penetrated. This fill was slightly organic in nature and was underlain by loose to dense sandy silt till. The upper 3 or 4 feet of the till appeared to be quite loose with N values as low as 9 blows per foot but generally increasing below a depth of 15 feet, that is, elevation 72, to dense with N values of 28 to 38 blows per foot. Natural water content of the till was found to vary from about 7 to 11 per cent.

Underlying the sand and gravel in borehole 2, loose brown sand was penetrated to a depth of 9 feet. This sand was also slightly organic in nature, and was underlain by dense to very dense sandy silt till below a depth of about 9 feet. The sandy silt till in this borehole had N values varying from 55 to greater than 100 blows per foot with a natural water content of about 7 per cent. Typical grain size distribution curves for the sandy silt till are presented as Figure 2.

This variation in the density of the till between the two boreholes probably represents the existence of a former stream bed in the area of borehole 1 which resulted in the softening of the upper part of the till stratum.

Groundwater seepage was observed into both boreholes at about elevation 78 during drilling and the stabilized groundwater level as measured in borehole 1 on April 6, 1970, was at about elevation 80 which approximately corresponds with the river water level on that date.

DISCUSSION

It is proposed to replace the existing 48 foot span Box Bridge with a new wider structure. It is recommended that the proposed bridge be founded on spread footings bearing on the dense to very dense sandy silt till with a maximum allowable bearing pressure of 4 tons per square foot. The footings should be founded on the west side at or below elevation 78 and on the east side at or below elevation 73.

Some seepage of groundwater can be expected into the excavations for both footings. However, it is considered that

this seepage will be minor in nature and can be easily handled by pumping from sumps.

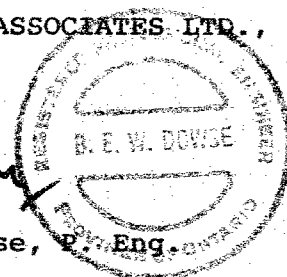
We trust that this letter provides sufficient information for the design of the proposed new bridge. If any point requires further clarification, do not hesitate to contact our office.

Yours truly,

H. Q. GOLDER & ASSOCIATES LTD.,

Brian E. W. Dowse

Brian E. W. Dowse,



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LIST OF ABBREVIATIONS

The abbreviations commonly employed on each "Record of Borehole," on the figures and in the text of the report, are as follows:

I. SAMPLE TYPES

AS auger sample
CS chunk sample
DO drive open
DS Denison type sample
FS foil sample
RC rock core
ST slotted tube
TO thin-walled, open
TP thin-walled, piston
WS wash sample

II. PENETRATION RESISTANCES

Dynamic Penetration Resistance: The number of blows by a 140-pound hammer dropped 30 inches required to drive a 2-inch diameter, 60 degree cone one foot, where the cone is attached to 'A' size drill rods and casing is not used.

Standard Penetration Resistance, *N*: The number of blows by a 140-pound hammer dropped 30 inches required to drive a 2-inch drive open sampler one foot.

WH sampler advanced by static weight—weight, hammer
PH sampler advanced by pressure—pressure, hydraulic
PM sampler advanced by pressure—pressure, manual

III. SOIL DESCRIPTION

(a) Cohesionless Soils

| <i>Relative Density</i> | <i>N, blows/ft.</i> |
|-------------------------|---------------------|
| Very loose | 0 to 4 |
| Loose | 4 to 10 |
| Compact | 10 to 30 |
| Dense | 30 to 50 |
| Very dense | over 50 |

(b) Cohesive Soils

| <i>Consistency</i> | <i>c_u, lb./sq. ft.</i> |
|--------------------|-----------------------------------|
| Very soft | Less than 250 |
| Soft | 250 to 500 |
| Firm | 500 to 1,000 |
| Stiff | 1,000 to 2,000 |
| Very stiff | 2,000 to 4,000 |
| Hard | over 4,000 |

IV. SOIL TESTS

C consolidation test
H hydrometer analysis
M sieve analysis
MH combined analysis, sieve and hydrometer¹
Q undrained triaxial²
R consolidated undrained triaxial²
S drained triaxial
U unconfined compression
V field vane test

NOTES:

¹Combined analyses when 5 to 95 per cent of the material passes the No. 200 sieve.

²Undrained triaxial tests in which pore pressures are measured are shown as \bar{Q} or \bar{R} .

LIST OF SYMBOLS

I. GENERAL

| | |
|---------------------------|-------------------------------------|
| π | = 3.1416 |
| e | = base of natural logarithms 2.7183 |
| $\log_e a$ or $\ln a$ | natural logarithm of a |
| $\log_{10} a$ or $\log a$ | logarithm of a to base 10 |
| t | time |
| g | acceleration due to gravity |
| V | volume |
| W | weight |
| M | moment |
| F | factor of safety |

II. STRESS AND STRAIN

| | |
|--------------|--|
| u | pore pressure |
| σ | normal stress |
| σ' | normal effective stress ($\bar{\sigma}$ is also used) |
| τ | shear stress |
| ϵ | linear strain |
| ϵ_m | shear strain |
| ν | Poisson's ratio (μ is also used) |
| E | modulus of linear deformation (Young's modulus) |
| G | modulus of shear deformation |
| K | modulus of compressibility |
| η | coefficient of viscosity |

III. SOIL PROPERTIES

(a) Unit weight

| | |
|------------|---|
| γ | unit weight of soil (bulk density) |
| γ_s | unit weight of solid particles |
| γ_w | unit weight of water |
| γ_d | unit dry weight of soil (dry density) |
| γ' | unit weight of submerged soil |
| G_s | specific gravity of solid particles $G_s = \gamma_s / \gamma_w$ |
| e | void ratio |
| n | porosity |
| w | water content |
| S_r | degree of saturation |

(b) Consistency

| | |
|-----------|--|
| w_L | liquid limit |
| w_P | plastic limit |
| I_P | plasticity index |
| w_S | shrinkage limit |
| I_L | liquidity index = $(w - w_P) / I_P$ |
| I_C | consistency index = $(w_L - w) / I_P$ |
| e_{max} | void ratio in loosest state |
| e_{min} | void ratio in densest state |
| D_r | relative density = $(e_{max} - e) / (e_{max} - e_{min})$ |

(c) Permeability

| | |
|-----|-------------------------------|
| h | hydraulic head or potential |
| q | rate of discharge |
| v | velocity of flow |
| i | hydraulic gradient |
| k | coefficient of permeability |
| j | seepage force per unit volume |

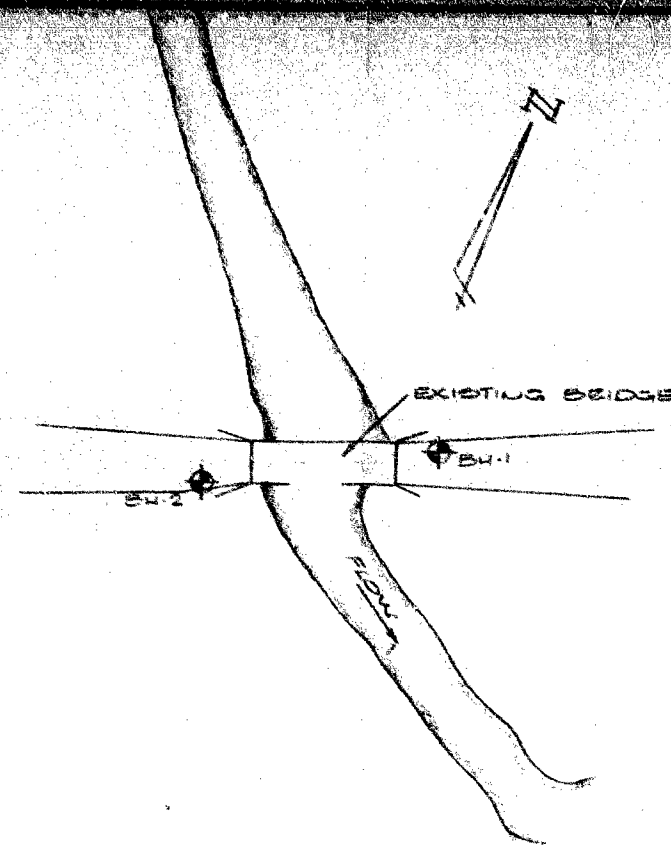
(d) Consolidation (one-dimensional)

| | |
|-------|--|
| m_v | coefficient of volume change = $-\Delta e / (1+e) \Delta \sigma'$ |
| C_c | compression index = $-\Delta e / \Delta \log_{10} \sigma'$ |
| c_s | coefficient of consolidation |
| T_v | time factor = c_v / d^2 (d , drainage path) |
| U | degree of consolidation |

(e) Shear strength

| | |
|----------|---|
| τ_f | shear strength |
| c' | effective cohesion |
| ϕ' | effective angle of shearing resistance, or friction |
| c_u | apparent cohesion* |
| ϕ_u | apparent angle of shearing resistance, or friction |
| μ | coefficient of friction |
| S_i | sensitivity |

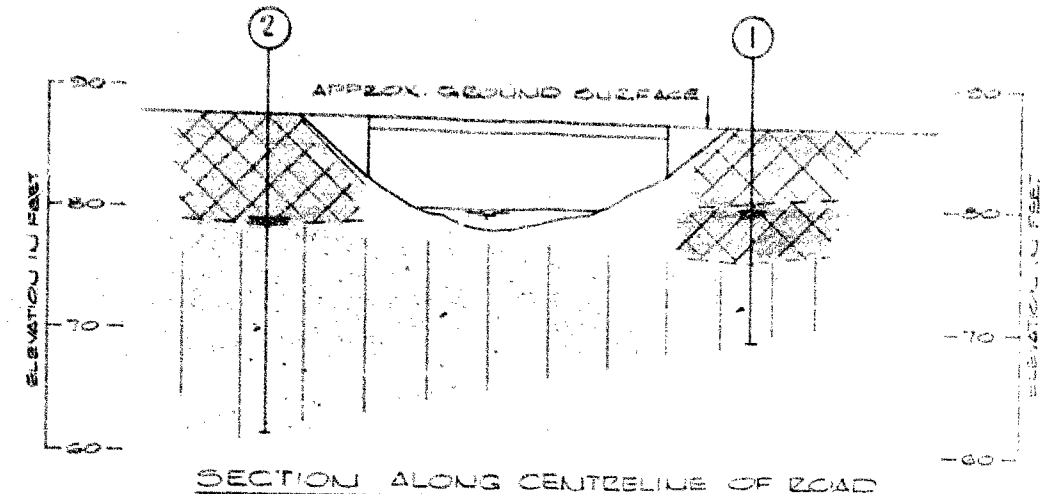
*For the case of a saturated cohesive soil, $\phi_u = 0$ and the undrained shear strength $\tau_f = c_u$ is taken as half the undrained compressive strength.



PLAN
SCALE: 1" = 40'

- LEGEND**
- ◆ - BOREHOLE IN PLAN
 - ② - BOREHOLE IN ELEVATION
 - ⊕ - WATER LEVEL IN BOREHOLE
APRIL 9, 1970
MARCH 8, 1970

REFERENCE
PLAN ENTITLED "BOX BRIDGE"
R.C. DUNN CONSULTING, INC.
D.W.S. DATED MARCH 4, 1970
SCALE: 1" = 40'



- STRATIGRAPHY**
- ▨ - DENSE BROWN SAND AND GRAVEL (FILL)
 - ▩ - STIFF BROWN CLAYEY SILT (FILL)
 - ▤ - LOOSE TO VERY DENSE GRAY SANDY SILT (TILL)

NOTE
Data concerning the various strata have been obtained at borehole locations only. The soil stratigraphy between the boreholes has been inferred from geological evidence and so may vary from that shown.
For detailed stratigraphy at each borehole location refer to the record of borehole sheets.

Date: APRIL 9, 1970

Golder Associates

Drawn: V.J.K.
Chkd: D.J.K.
Appd: J.K.

FIGURE 2

