#67-F-263 M

NEEDHAM BRIDGE

CON. 9/10, LOT 10

LONDON TWP.

H. Q. GOLDER & ASSOCIATES LTD.

SOIL AND FOUNDATION ENGINEERS

HEAD OFFICE - TORONTO ONTARIO

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747 HYDE PARK ROAD
LONDON ONTARIO
471-0600

November 29, 1967.

Con 9 & 10 Lot 10

R. C. Dunn & Associates Ltd.,
747 Hyde Park Road,
LONDON, Ontario.

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

RE: Subsurface Investigation,
Needham Bridge, London Township,
Middlesex County, Ontario

Dear Sirs:

This letter reports the results of a subsurface investigation carried out at the site of the proposed reconstruction of Needham Bridge, located on the road between Concession **IX** and **X**, at Lot 10 in the Township of London, Middlesex County, Ontario. It is proposed to replace the existing structure with a 75 foot reinforced concrete bridge.

Two boreholes were put down on November 20th, 1967 at the locations shown on Figure 1, using a trailer mounted power auger. Standard penetration tests were carried out in both boreholes and the samples obtained brought to our London laboratory for detailed examination and representative testing. The ground-water level was observed in both boreholes during drilling and in a perforated standpipe installed in Borehole 2 on the completion of drilling.

The soil conditions encountered in the boreholes are shown in detail on the Record of Borehole sheets attached to this letter and an inferred soil stratigraphy across the site is shown with the Site Plan as Figure 1. The results of the laboratory testing are shown on the Records of Boreholes and on Figure 2.

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The elevations given in this letter are referred to a bench mark located as a red paint mark on the top of the northwest corner of the wingwall on the existing bridge. The elevation of this bench mark was given as 80.83 referred to a local datum.

The site is located within the physiographic region known as the Stratford Till Plain. The Medway River over which the structure will be built flows south to join the north branch of the Thames River through rolling agricultural land.

The borings put down at the side of the existing roadway show that below the roadway material there is about 8 to 10 feet of soft to firm brown to dark brown clayey silt fill behind the existing abutments. Below the fill, there was a very stiff to hard grey clayey silt till with occasional gravel overlain by 1 to 2 feet of dense grey sand and gravel. The till forms the major underlying stratum at the site and has a natural water content of about 15 per cent with a liquid and plastic limit of about 30 and 15, respectively. Typical grain size distribution curves for the till are shown as Figure 2. The ground-water level was measured during drilling to be between Elevation 73 and 76.

The proposed structure may be founded on spread footings in the till at Elevation 66 or deeper with an allowable bearing pressure of 4 tons per square foot.

If it is proposed to use retaining type abutments, it is recommended that free draining and non-frost-susceptible granular backfill be used behind the abutments. The granular backfill should be compacted in thin horizontal lifts and should extend horizontally from the back face of the abutment walls for a minimum distance of 4 feet. A maximum loose lift thickness of 18 inches should be used and compacted with vibratory equipment. It is recommended that providing there is effective drainage behind the walls, a co-efficient of earth pressure at rest of 0.5 and a total unit weight of 130 pounds per cubic foot be used for the compacted granular backfill in the design of the rigid walls.

..3

There should be only minor ground-water problems during construction, providing the river is properly diverted. Any seepage into the excavations can be easily handled with small sump pumps.

We trust that this letter provides sufficient information for the foundation design of the proposed structure. If there is any point that requires further explanation, please call our office.

Yours truly,

H. Q. GOLDER & ASSOCIATES LTD.,

Brian E. W. Dowse, P. Eng.

REGISTERED PROFESSIONAL ENGINEER
B. E. W. DOWSE
PROVINCE OF ONTARIO

BEWD:cmm
67590
November, 1967

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*

Relative Density	*N, blows/ft.*
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) *Cohesive Soils*

Consistency	c_u, *lb./sq. ft.*
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 hydrometer[1]
Q	undrained triaxial[2]
R	consolidated undrained triaxial[2]
S	drained triaxial
U	unconfined compression
V	field vane test

NOTES:

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

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

LIST OF SYMBOLS

I. GENERAL

$\pi = 3.1416$

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_{xy} 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_v coefficient of consolidation
- T_v time factor $= c_v t/d^2$ (d, drainage path)
- U degree of consolidation

(e) *Shear strength*

- τ_f shear strength
- c' effective cohesion intercept; ϕ' effective angle of shearing resistance, or friction — in terms of effective stress $\tau_f = c' + \sigma' \tan \phi'$
- c_u apparent cohesion*; ϕ_u apparent angle of shearing resistance, or friction — in terms of total stress $\tau_f = c_u + \sigma \tan \phi_u$
- μ coefficient of friction
- S_t 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.

PROJECT NO. [illegible]

DEFECTS IN NEGATIVE DUE TO CONDITION OF ORIGINAL DOCUMENT

RECORD OF BOREHOLE 1

LOCATION See Figure 1 BORING DATE NOV 20, 1967 DATUM LOCAL

BOREHOLE TYPE POWER AUGER BORING BOREHOLE DIAMETER 4.5"

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES PEN. TEST HAMMER WEIGHT - LB. DROP - INCHES

ELEVN. / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	BLOWS / FT.	ADDITIONAL LAB. TESTING
78.4	GROUND SURFACE				
0.0 – 76.4	LOOSE SAND AND GRAVEL ROADBASE				
2.0 – 68.4	SOFT TO FIRM BROWN TO DARK BROWN CLAYEY SILT FILL WITH OCCASIONAL SAND AND GRAVEL (FILL)	1	2" D.O.	13	
		2	"	12	
		3	"	32	
10.0 – 66.4	COMPACT TO DENSE SAND AND GRAVEL OCCASIONAL COBBLES	4	"	84	
12.0 – 21.5	HARD GREY CLAYEY SILT TILL WITH OCCASIONAL SAND AND GRAVEL	5	"	34	MH
		6	"	81	
		7	"	100	
		8	"	34	
56.9	END OF HOLE				

Columns: STRAT. PLOT; ELEVATION SCALE (80, 75, 70, 65, 60, 55); DYNAMIC PENETRATION RESISTANCE BLOWS/FT.; SHEAR STRENGTH C_u, LB./SQ.FT.; COEFFICIENT OF PERMEABILITY k, CM./SEC.; WATER CONTENT, PERCENT W_p W W_L (10, 20, 30, 40); PIEZOMETER OR STANDPIPE INSTALLATION

WATER LEVEL AT ELEVATION 72.7 DURING DRILLING NOV 20, 1967

15-○-5 (0, 10) Percent axial strain at failure

VERTICAL SCALE 1 INCH TO 5'-0"

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RECORD OF BOREHOLE 2

LOCATION See Figure 1 | BORING DATE NOV. 20, 1967 | DATUM LOCAL

BOREHOLE TYPE POWER AUGER BORING | BOREHOLE DIAMETER 4.5"

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 INCHES | PEN. TEST HAMMER WEIGHT - LB. DROP - INCHES

ELEVN. / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	BLOWS / FT.	WATER CONTENT (W)	ADDITIONAL LAB. TESTING
80.5	GROUND SURFACE					
0.0 / 79.0	LOOSE SAND AND GRAVEL ROADBASE					
1.5	SOFT TO FIRM BROWN TO DARK BROWN CLAYEY SILT FILL WITH OCCASIONAL SAND AND GRAVEL (FILL)	1	2" D.O.	11	o	
		2	"	12	o	
		3		50	o	
		4	"	19	o	
69.0	COMPACT TO DENSE SAND & GRAVEL OCC. COBBLES					
68.0 / 12.5	HARD GREY CLAYEY SILT TILL WITH OCCASIONAL SAND AND GRAVEL	5	"	53	o	
		6	"	100	o	MH
		7	"	200	o	
		8	"	>100	o	
24.0		9		97	o	
56.5	END OF HOLE					

ELEVATION SCALE: 85, 80, 75, 70, 65, 60, 55

DYNAMIC PENETRATION RESISTANCE BLOWS/FT. ----------

SHEAR STRENGTH C_u, LB./SQ.FT.

COEFFICIENT OF PERMEABILITY k, CM./SEC.

WATER CONTENT, PERCENT W_P — W — W_L : 10, 20, 30, 40

PIEZOMETER OR STANDPIPE INSTALLATION:
- GROUND SURFACE
- SAND FILL
- PERFORATED PLASTIC PIPE
- CAVE IN MATERIAL
- WATER LEVEL IN STANDPIPE AT ELEVATION 76.5 NOV 20, 1967

15 -o- 5 Percent axial strain at failure (10)

VERTICAL SCALE 1 INCH TO 5'-0"

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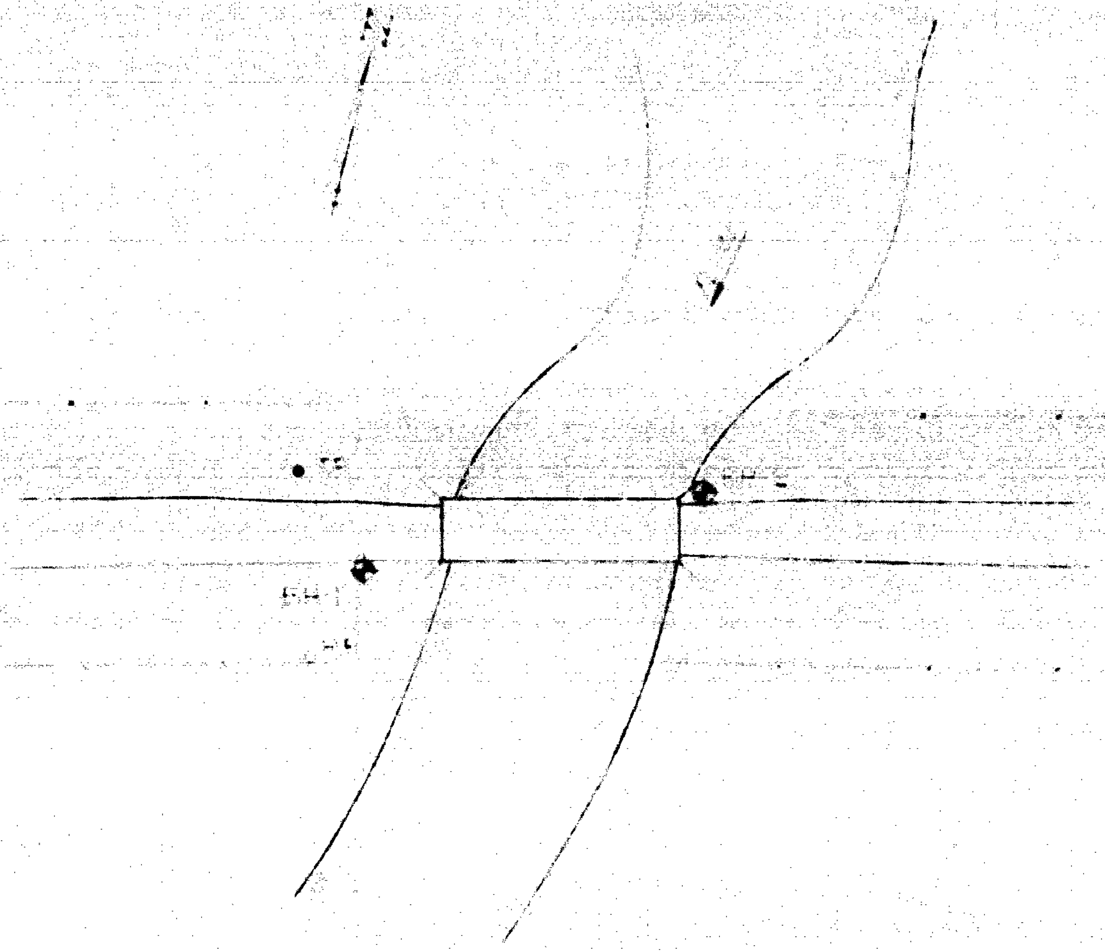
BORING PLAN & SECTION

FIGURE 1

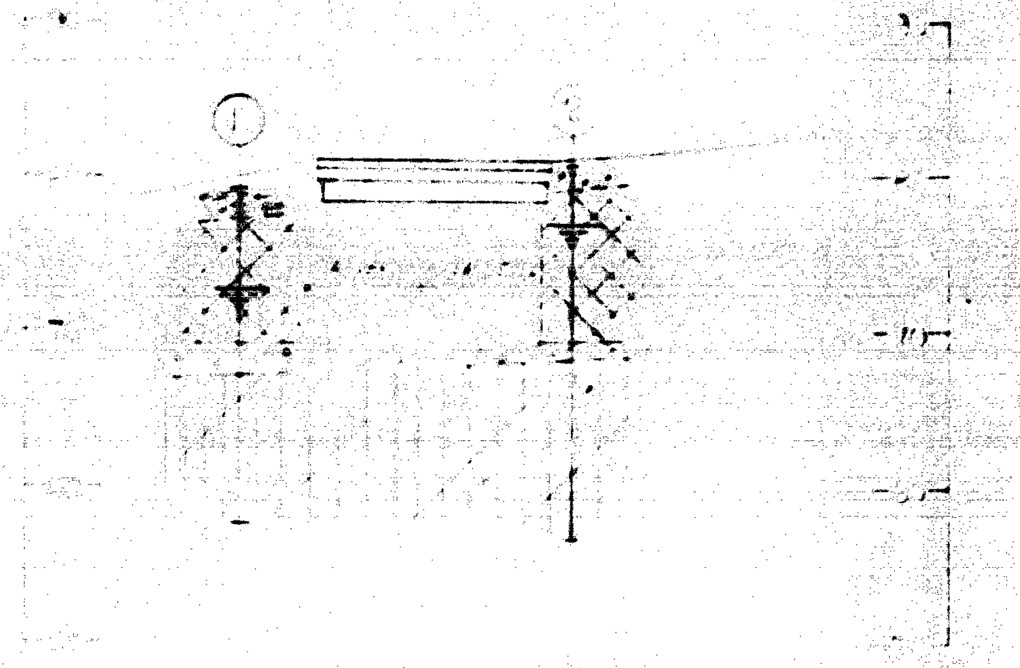


PLAN

REFERENCE

TOWNSHIP OF LONDON

NEEDHAM BRIDGE



SECTION ALONG CENTRELINE OF ROAD

STRATIGRAPHY

- LOOSE SAND AND GRAVEL - **ROADBASE**
- **(FILL)**
- **SAND AND GRAVEL**
- **SILT TILL**

LEGEND

SPECIAL NOTE: DATA CONCERNING THE VARIOUS STRATA HAVE BEEN OBTAINED AT BOREHOLE LOCATIONS ONLY. THE ... BOREHOLES HAS ... EVIDENCE AND SO MAY VARY FROM THAT SHOWN

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Drawn NOV 21, 1967

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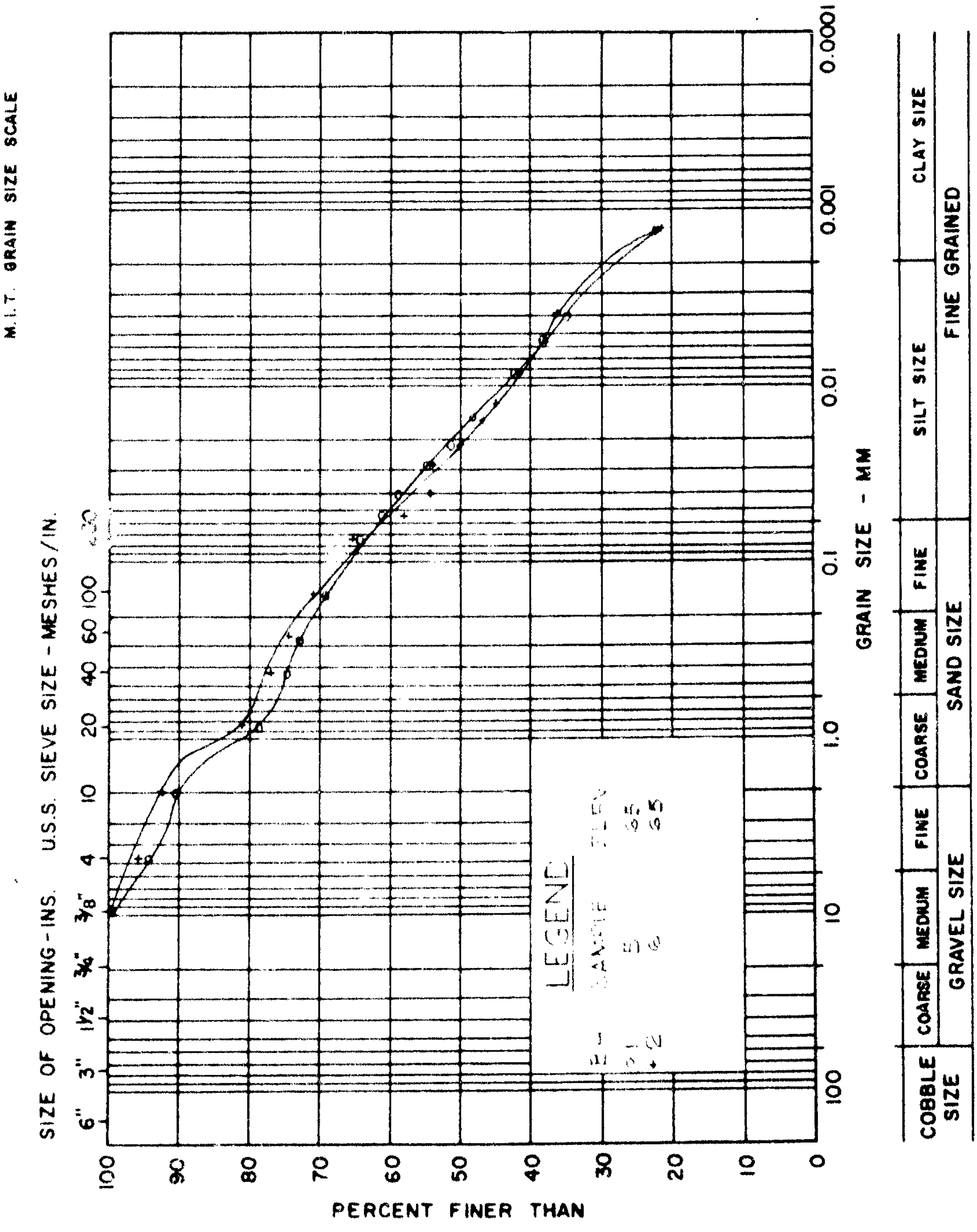
GRAIN SIZE DISTRIBUTION

TILL

FIGURE 2



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