#68-F-234M

NORTH ISLAND

BRIDGE

CHARLOTTENBURGH

BA 2978
Site 31-185

H. Q. GOLDER & ASSOCIATES LTD.

SOIL AND FOUNDATION ENGINEERS
HEAD OFFICE - TORONTO, ONTARIO

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March 11, 1968.

R. M. Kostuch Associates Ltd.,
Consulting Engineers,
238 King Street West,
P. O. Box 663,
Brockville, Ontario.

Attention: Mr. R. M. Kostuch, P. Eng.

RE: Soil Investigation,
Proposed North Island Bridge,
Township of Charlottenburgh.

Dear Sirs:

This letter reports the results of a soil investigation carried out at the above bridge site. The purpose of this investigation was to determine the soil conditions at the site and based on this information to make recommendations for foundation design for the proposed bridge structure.

PROCEDURE

The field work for this investigation was carried out on February 29, March 1, and March 5, 1968. One borehole with accompanying dynamic penetration test was put down on the north side of the bridge. Dynamic penetration tests were attempted on the south side of the bridge but met refusal in the bouldery approach embankment fill. On March 5, a dynamic penetration test was finally successful in penetrating the fill, though well back from the abutment location. The boring and penetration tests were put down with a machine drill rig supplied and operated by the F. E. Johnston Drilling Co. Ltd. The field work was supervised by a member of our engineering staff.

The location of the boring and the penetration test, together with a stratigraphic section along the centerline of the proposed bridge, are shown on Figure 1. A detailed log of the borehole is given on the Record of Borehole sheet following the text of this report.

The soil samples were brought to our laboratory for examination and testing. The results of a laboratory test on the glacial till are shown on Figure 2.

The elevations given in this report are referred to the bench mark located on the end of the steel truss at the north east corner of the bridge. The elevation of this bench mark was given to us as 101.50 as referred to a local datum.

SITE AND GEOLOGY

The bridge site is located some 9 miles north of Cornwall and 1 mile west of Martintown. The topography of the area surrounding the North Raisan River is flat to gently rolling.

From available geological information it is known that the area is generally covered with glacial till overburden. Clay deposits exist within the river valley. The underlying bedrock is limestone of the Ottawa formation.

SUBSURFACE CONDITIONS

The detailed soil stratigraphy encountered in the borehole is given on the Record of Borehole sheet. Following is a summarized account of the soil conditions.

The approach embankments to the bridge consist of granular fill, some 9 feet thick. Near the surface the fill generally consisted of silty sand and with depth the material changed to a gravelly sand. Boulders were encountered throughout the fill depth. At the borehole location, 1.5 feet of loose alluvium (flood plain deposit) consisting of dark grey brown sandy silt was encountered.

Underlying the alluvium deposit, is a stratum of clayey silt till, the principal foundation stratum at the site. The thickness of the stratum at the borehole location is 10 feet. A grain size distribution test was carried out on a sample from the till and the results are shown on Figure 2. Standard penetration tests in the clayey till gave "N" values of 32 and 50 blows/ft. Based on these values and the results of the dynamic penetration tests, the consistency of the clayey silt till is considered to be hard.

At a depth of about 20 feet below roadway level, a stratum of very dense silty sand was encountered. The borehole was terminated in this stratum.

A standpipe was installed in the borehole in the silty sand material. The water level in the standpipe on March 5, 1968, 4 days after completion of boring,was at elevation 90, or about 2 feet above ice level.

PROPOSED BRIDGE STRUCTURE

a) General

It is understood that it is proposed to replace the narrow existing North Island bridge with a two lane bridge immediately east of the existing bridge. The proposed structure will be a one span bridge 60 feet in length and on a 30 degree skew to the North Raisan River. It is not known at this time whether the bridge will be simply supported or of rigid frame construction. During reconstruction of the bridge,the approach embankment levels will not be altered significantly.

b) Foundations

It is recommended that the abutments of the proposed bridge be founded on spread footings placed in the clayey silt till which underlies the site at about river bed level. To provide adequate frost protection the footings should be taken down at least 5 feet below the low river level. This depth will provide some scour protection.

The "N" values and the dynamic penetration resistances obtained within the till stratum are in excess of 30 blows/ft. Based on these values, an allowable bearing pressure of 3 tons/sq.ft. may be used in design of footings founded in the clayey silt till. With this allowable bearing pressure there should be no detrimental settlement of the bridge abutment footings, provided precautions are taken during construction, as discussed below, to prevent softening of the clayey silt till at and below foundation grade.

In the computation of sliding resistance between a concrete footing base and the roughened surface of the undisturbed clayey silt till subsoil, an adhesion of 3,000 lb/sq.ft. may be used.

Closed end abutments should be backfilled for a distance of at least 5 feet horizontally with a well compacted, free draining, and non-frost-susceptible granular material. Provision should also be made for drainage from the backfill to prevent hydrostatic ice pressure built up behind the walls. With full effective drainage of the backfill, a coefficient of lateral earth pressure at rest, Ko, = 0.4 and a total unit weight of 135 lb/cu.ft. should be used for the compacted granular backfill in design of the abutments of a rigid frame structure. For a simply supported structure in which some movement of the top of the wall could be tolerated, a active earth pressure coefficient, Ka, = 0.3 may be used.

Construction Procedures

The footing excavations should be surrounded with dykes of relatively impervious glacial till. The dykes should be founded on the underlying clayey silt till and should be built up to a level at least 2 feet above the expected high water level during the foundation construction period. The water inflow into the excavations should then be minor and should be readily handled by pumping from sumps.

To prevent softening of the till due to surface water or construction operations, it is recommended that the base of the footing excavation, once foundation grade is reached, be immediately covered by a mud mat of lean concrete.

Approach Embankments

It is understood that the grade of the approach embankments will not be raised significantly at this bridge crossing. For approach embankment levels of 10 feet above the river flood plain level and resting on the hard clayey silt till, there should be no stability problem, using 2 horizontal to 1 vertical side slopes and suitable fill material.

All surficial topsoil and organic matter should be removed beneath the full base width of the embankments prior to their construction.

We trust that this report contains sufficient information for your design purposes. If we can be of any further service to you on this project, please call us.

Yours very truly,

H. Q. GOLDER & ASSOCIATES LTD.

F. J. Heffernan

F. J. Heffernan, P. Eng.

FJH/ml
68755A
March, 1968.

REGISTERED PROFESSIONAL ENGINEER
F. J. HEFFERNAN
PROVINCE OF ONTARIO

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.

GOLDER & ASSOCIATES

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 $\bar{R}$.

RECORD OF BOREHOLE 1

LOCATION See Figure 1 BORING DATE [illegible] DATUM [illegible]

BOREHOLE TYPE [illegible] BOREHOLE DIAMETER [illegible]

SAMPLER HAMMER WEIGHT [illegible] LB. DROP [illegible] INCHES PEN. TEST HAMMER WEIGHT LB DROP INCHES

ELEVN. / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	BLOWS / FT.	ELEVATION SCALE	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
98.7	GROUND LEVEL				100		GROUND LEVEL
0.0	COMPACT TO DENSE BROWN SANDY SILT AND BOULDERS GRADING TO GRAVELLY SANDY, SOME SILT, **(EMBANKMENT FILL)**	1	[illegible]				SURFACE SEAL
		2	[illegible]	17			SAND FILL
		3		38			
89.7 / 9.0	LOOSE DARK BROWN ORGANIC SANDY SILT **(ALLUVIUM)**	4		[illegible]	90		[illegible] TUBING
88.2 / 10.5	HARD GREY CLAYEY SILT, SOME SAND AND GRAVEL, OCCASIONAL BOULDERS **(CLAYEY SILT TILL)**	5		[illegible]		MH	
					80		STANDPIPE
78.2 / 20.5	VERY DENSE GREY **SILTY SAND**, SOME SILT LAYERS	6		65			
76.4 / 22.3	END OF HOLE						
					70		

W.L. IN STANDPIPE AT ELEV. 89.7 ON MAR. 5, 1968

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

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

VERTICAL SCALE 1 INCH TO 5'

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CHECKED F.J.H.

DEFECTS IN NEGATIVE DUE TO
CONDITION OF ORIGINAL DOCUMENT

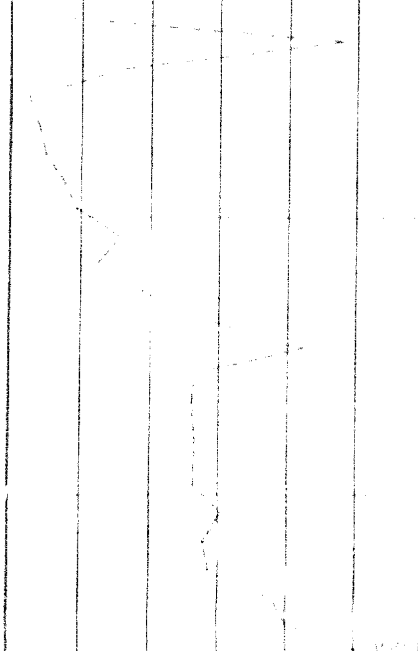
RECORD OF BOREHOLE

LOCATION See Figure | BORING DATE MAR [illegible] | DATUM [illegible]

BOREHOLE TYPE [illegible] | BOREHOLE DIAMETER [illegible]

SAMPLER HAMMER WEIGHT — LB. DROP — INCHES | PEN. TEST HAMMER WEIGHT [illegible] LB DROP 30 INCHES

SOIL PROFILE			SAMPLES			ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FT. (20 40 60 80 100) / SHEAR STRENGTH C_u, LB./SQ.FT	COEFFICIENT OF PERMEABILITY k, CM/SEC / WATER CONTENT, PERCENT W_P W W_L	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
ELEVN. / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	BLOWS/FT.					
						100				
97.4	GROUND LEVEL									
0.0	PROBABLY COMPACT TO DENSE SAND, GRAVEL, SILT AND BOULDERS (EMBANKMENT FILL)									
						90				
89.4 / 8.0	PROBABLY LOOSE SANDY SILT (ALLUVIUM)									
87.9 / 9.5	PROBABLY HARD CLAYEY SILT TILL									
						80				
77.4 / 20.0	PROBABLY VERY DENSE SILTY SAND									
74.6 / 22.8	END OF PEN. TEST						[illegible] BLOWS ON LAST 6"			
						70				



15 ○ 5 (10) Percent axial strain at failure

VERTICAL SCALE
1 INCH TO 5'

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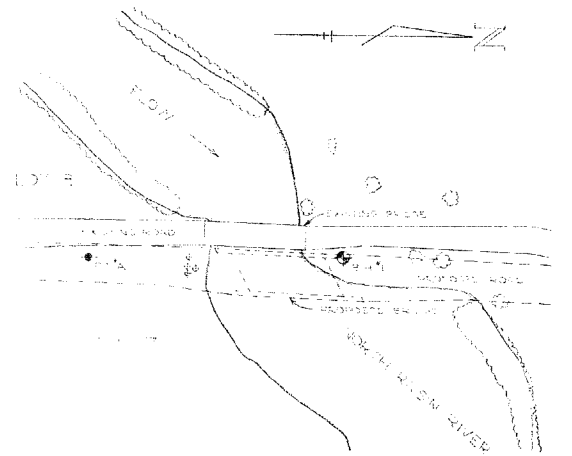
CHECKED F.J.H.

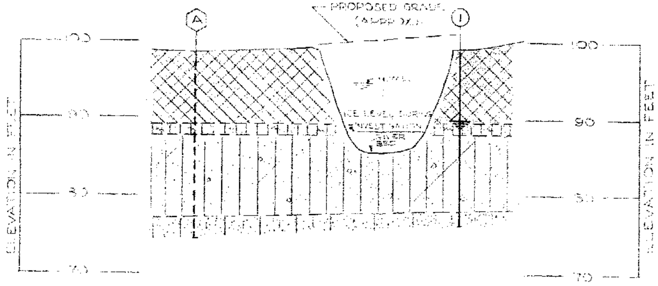
BORING PLAN AND SOIL STRATIGRAPHY
(NORTH ISLAND BRIDGE)

FIGURE 1



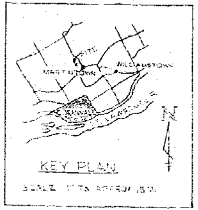
PLAN

SCALE: 1" TO 50'



SECTION ALONG PROPOSED ℄

SCALES: HOR. 1" TO 50'
VER. 1" TO 10'



KEY PLAN

LEGEND

- BOREHOLE IN PLAN
- PENETRATION TEST IN PLAN
- PENETRATION TEST, REFUSAL IN EMBANKMENT FILL, IN ELEVATION
- BOREHOLE IN ELEVATION
- PENETRATION TEST IN ELEVATION
- WATER LEVEL IN ELEVATION

STRATIGRAPHY

- COMPACT TO DENSE BROWN SANDY SILT AND BOULDERS, GRADING TO GRAVELLY SAND, SOME SILT. **(EMBANKMENT FILL)**
- LOOSE DARK BROWN ORGANIC SANDY SILT **(ALLUVIUM)**
- HARD GREY CLAYEY SILT, SOME SAND AND GRAVEL, OCCASIONAL BOULDERS **(CLAYEY SILT TILL)**
- VERY DENSE GREY **SILTY SAND** SOME SILT LAYERS

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

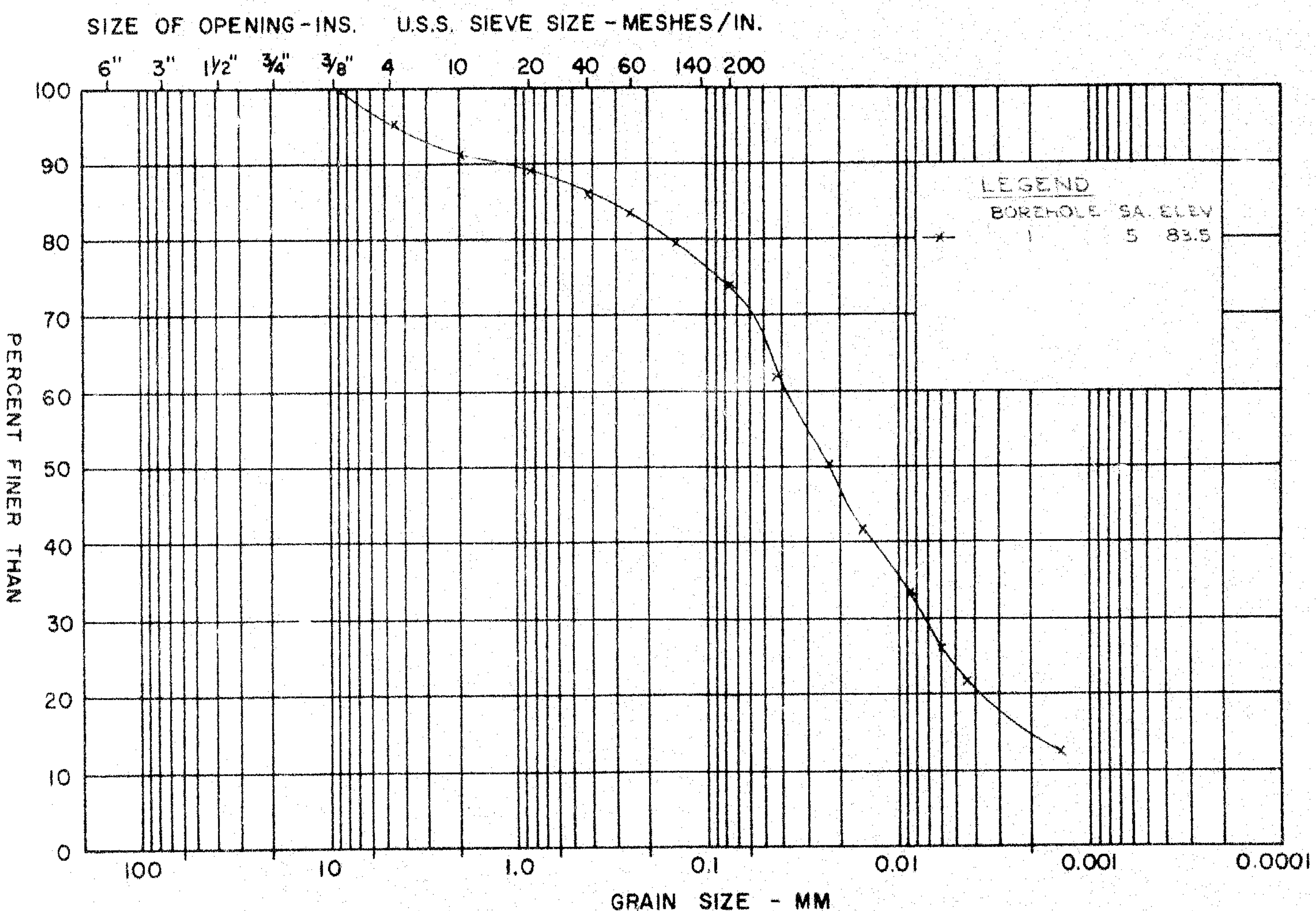
DEFECTS IN NEGATIVE DUE TO CONDITION OF ORIGINAL DOCUMENT

Drawn: MAR. 8, 1968.

GOLDER & ASSOCIATES

Made D.N.
Chkd.
Appd.

M.I.T. GRAIN SIZE SCALE



COBBLE SIZE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	SILT SIZE	CLAY SIZE
	GRAVEL SIZE			SAND SIZE			FINE GRAINED	

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GRAIN SIZE DISTRIBUTION

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FIGURE 2