

68-F-208 M

BRIDGE

CON. RD. XIII - XIV

NORMANBY TWP.

B.A. 2786
Site 8-268

H. Q. GOLDER & ASSOCIATES LTD.

SOIL AND FOUNDATION ENGINEERS

HEAD OFFICE - TORONTO, ONTARIO

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747 HYDE PARK ROAD
LONDON, ONTARIO
471-9600

February 9, 1968.

A. M. Mackay & Associates Limited,
935 Second Avenue West,
OWEN SOUND, Ontario.

68-E-208M

ATTENTION: Mr. L. Sparnaay

RE: Subsurface Investigation, Proposed
Bridge, Concession Road XIII - XIV,
Near Varney, Normanby Township,
Grey County, Ontario.

Dear Sirs:

This letter reports the results of a subsurface investigation carried out at the site of the proposed reconstruction of a bridge located on the road between Concessions XIII and XIV, Normanby Township, Grey County, about three miles west of Highway 6. It is proposed to replace the existing steel girder bridge with a reinforced concrete structure at its present location.

PROCEDURE

Two boreholes were put down between January 17 and 19, 1968, using a trailer mounted wash drillrig supplied and operated by P.V.K. and Sons. 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

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borehole 1 upon completion of drilling.

The soil conditions encountered in the boreholes are shown in detail on the Record of Boreholes sheet 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 Record of Boreholes and on Figure 2.

The elevations given in this letter are referred to a bench mark, namely a nail and washer in a one foot diameter elm tree located about 250 feet east of the proposed structure. The elevation of this point was given as 100.0 by A. M. Mackay & Associates, referred to a local datum.

SITE AND GEOLOGY

The site is located in the drainage basin of the Beatty River in the area known physiographically as the Horseshoe Moraines. The branch of the river over which the structure will be built flows northwest through virgin bush and partly developed rolling farmland. The moraine in this area is known to be overlain by various complex till ridges, kane-moraines, outwash plains and spillways.

SOIL CONDITIONS

The borings put down through the roadway at the site indicate that there is 5 to 6 feet of loose to very dense sand and gravel fill which contains some topsoil and is underlain in borehole 1 by a layer of peat about 4 inches thick. Below the fill, there is a dense to very dense grey sandy gravel with occasional cobbles which was encountered in both boreholes. The gravel has an average water content of about 10 per cent, and a typical grain size distribution curve is presented on Figure 2. Borehole 1 was carried through this stratum and indicated the thickness to be about 20 feet, while borehole 2 was terminated after penetrating the stratum for 11 feet. Below the gravel,

dense to very dense sandy silt was encountered in borehole 1. The average water content of this stratum was about 20 per cent and a typical grain size distribution curve is shown on Figure 2. The ground-water level was measured upon the completion of drilling to be at about elevation 97 which corresponds to the water level in the river at the time of the investigation.

FOUNDATION DESIGN

The proposed structure may be founded on spread footings on the gravel stratum at elevation 90 or deeper with a maximum allowable bearing pressure of 3 tons per square foot. The exact depth of the foundation below elevation 90 should be determined from the hydrology of the river so that adequate protection is provided against scour.

If it is proposed to use retaining type abutments, it is recommended that free draining and nonfrost-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 coefficient 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.

Ground-water problems will be encountered during excavation and construction of the abutment footings. The most economical method of dewatering the excavations can probably be obtained by diverting the river east of the bridge site and pumping from a series of sumps upstream of the site. Due to the relatively high permeability of the gravel stratum, this can most easily be carried out during the summer months when the river level will be lowest.

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4.

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.

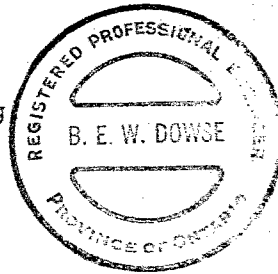
Yours truly,

H. Q. GOLDER & ASSOCIATES LTD.,

Brian E. W. Dowse

Brian E. W. Dowse, P. Eng

BEWD:cmn
68506
Feb., 1968



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

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

<i>WH</i>	sampler advanced by static weight—weight, hammer
<i>PH</i>	sampler advanced by pressure—pressure, hydraulic
<i>PM</i>	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

<i>C</i>	consolidation test
<i>H</i>	hydrometer analysis
<i>M</i>	sieve analysis
<i>MH</i>	combined analysis, sieve and hydrometer ¹
<i>Q</i>	undrained triaxial ²
<i>R</i>	consolidated undrained triaxial ²
<i>S</i>	drained triaxial
<i>U</i>	unconfined compression
<i>V</i>	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_{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_c	coefficient of consolidation
T_v	time factor = c_d / 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_t	sensitivity

$\left. \begin{array}{l} \text{in terms of effective stress} \\ \tau_f = c' + \sigma' \tan \phi' \end{array} \right\}$

$\left. \begin{array}{l} \text{in terms of total stress} \\ \tau_f = c_u + \sigma \tan \phi_u \end{array} \right\}$

*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.

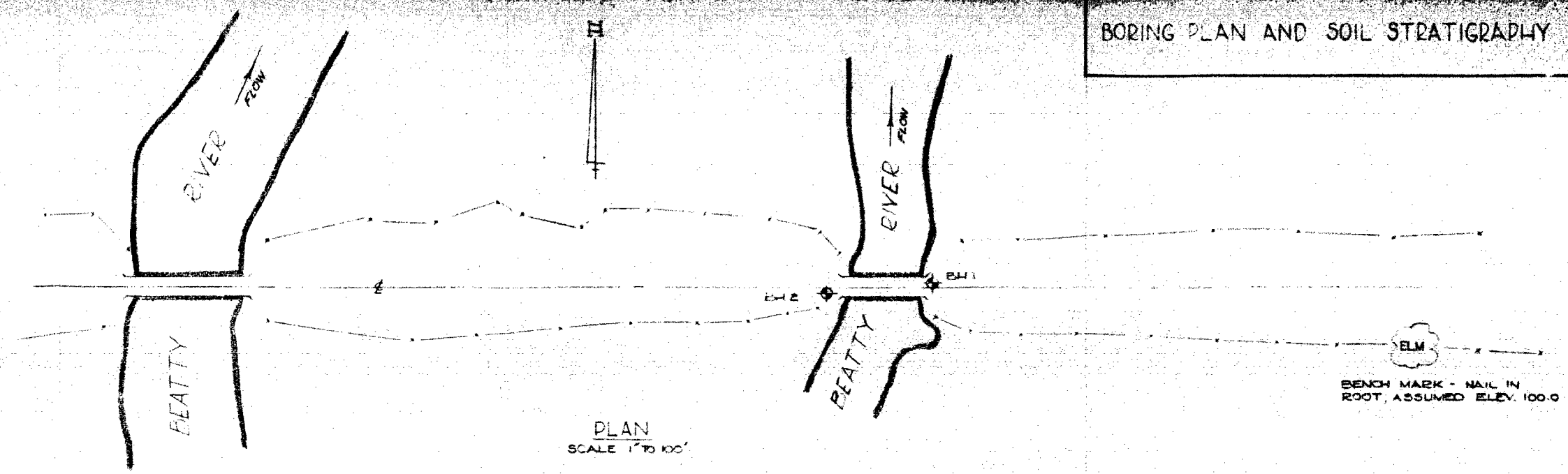
L² AL

PEN. TEST HAMMER WEIGHT - LB. DROP - INCHES

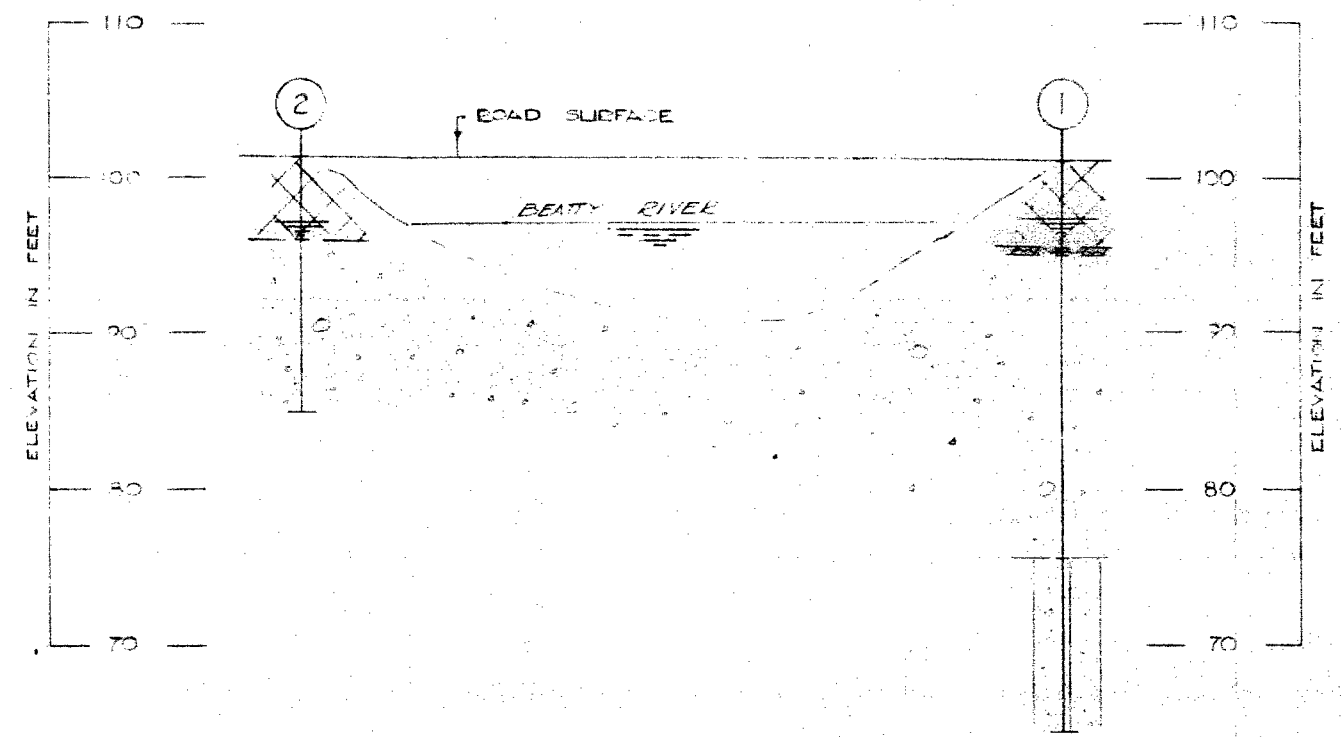
15-0-5 Percent axial strain at failure

DRAWN _____
CHECKED _____

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BENCH MARK - NAIL IN
ROOT, ASSUMED ELEV. 100.0



STRATIGRAPHY

- LOOSE TO VERY DENSE SILTY SAND AND GRAVE TRACE OF ORGANICS (FILL)
- BLACK PEAT
- DENSE TO VERY DENSE GREY SANDY GRAVEL OCCASIONAL COBBLES
- DENSE TO VERY DENSE SANDY SILT OCCASIONAL FINE GRAVEL

LEGEND

- BOREHOLE IN PLAN
- BOREHOLE IN ELEVATION
- WATER LEVEL IN BOREHOLE JAN. 19, 1968

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.

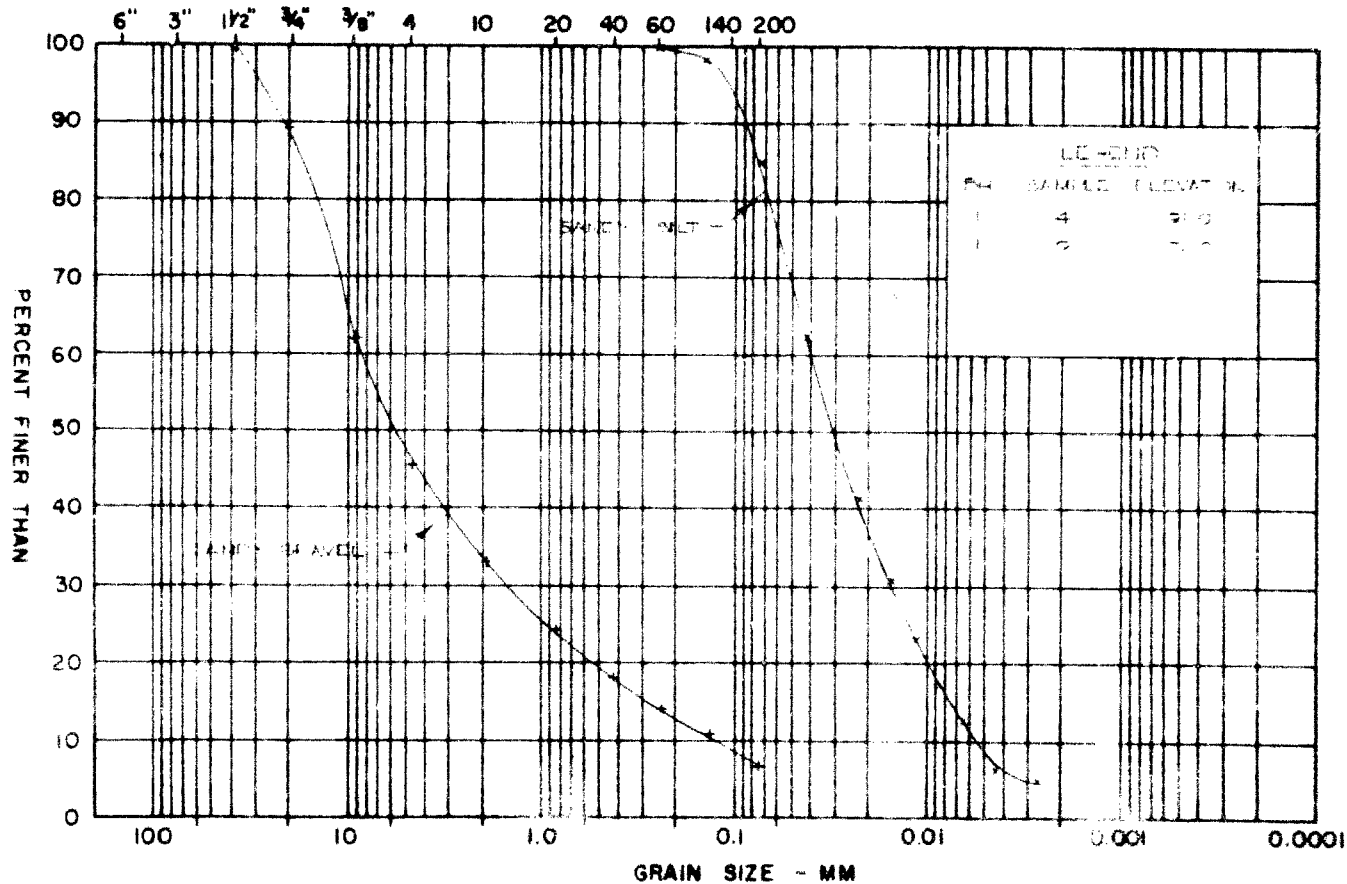
Drawn FEB. 8, 1968

GOLDER & ASSOCIATES

Made RL
Chkd _____
Appd _____

M.I.T. GRAIN SIZE SCALE

SIZE OF OPENING - INS. U.S.S. SIEVE SIZE - MESHES/IN.



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

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GRAIN SIZE DISTRIBUTION

FIGURE 2