64-F-247M

BRIDGE No. 44

TREMBLAY ROAD

OTTAWA QUEENSWAY

BA 1864

H. Q. GOLDER & ASSOCIATES LTD.

CONSULTING CIVIL ENGINEERS

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REPORT

TO

DE LEUW, CATHER & COMPANY OF CANADA LIMITED

ON

SITE INVESTIGATION

PROPOSED BRIDGE NO. 44 AT TREMBLAY ROAD

OTTAWA QUEENSWAY

OTTAWA ONTARIO

64-F-247M

Distribution:

10 copies - De Leuw, Cather & Company of Canada Limited, Ottawa, Ontario

2 copies - H. Q. Golder & Associates Ltd., Toronto, Ontario.

June, 1964 64047

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ABSTRACT

The results of a site investigation for Queensway Bridge No. 44 at Tremblay Road in Ottawa are reported.

It was found that the site was covered by fill from 3 feet in thickness to 8 feet where the proposed location encroached on an existing embankment. Beneath the fill is a dense till containing sand, silt and clay with some gravel. The till in the area of the proposed structure is 3 to 4.3 feet thick and is underlain by shale bedrock. Approximately the upper foot of the shale is weathered and broken, below that it is sound.

In the borehole to check on the soil under the proposed approach embankments a thin layer of silt and peat was encountered. This may be fill or the original surface deposit. The material encountered is not considered to be critical for embankment stability.

It is recommended that the bridge structure be founded directly on the unweathered shale or on steel piles driven to refusal in the shale.

Groundwater levels were measured in the boreholes and indicate some dewatering will be necessary in order to place footings directly on the shale.

INTRODUCTION

H. Q. Golder & Associates Ltd. were retained by De Leuw, Cather and Company of Canada Ltd., Consulting Engineers, to carry out a soil investigation at the site of the proposed Bridge No. 44 at Tremblay Road on the Queensway in Ottawa, Ontario. The purpose of this investigation was to determine the subsoil conditions at the site and to provide information relating to the foundation design.

PROCEDURE

The field work for this investigation was carried out during the period May 5 to May 8, 1964, using a mobile power auger and diamond drilling equipment. A total of five boreholes was put down at the site, four under the proposed abutments and piers and one about 125 feet south of the structure. Bedrock was proven in the four holes under the structure by diamond drilling approximately 10 feet into the rock. The fifth borehole was put down to check the soil under the embankment and to ensure that rock was at approximately the same elevation as in the other boreholes. Standpipes or piezometers were installed in the first four boreholes to allow the taking of water level readings.

A detailed log for each borehole is given on the Records of Boreholes following the text of this report. The location of the borings and a section of the inferred soil stratigraphy across the site are given on Figure 1.

The samples obtained during the investigation were brought to our laboratory for examination and testing. Natural water contents, Atterberg limits and grain size analyses were carried out on six selected samples. The results of the water content and Atterberg limit tests are given on the Records of Boreholes and the results of the grain size analyses are given on Figures 2 and 3.

The elevations for the ground surface at the boreholes were supplied by De Leuw, Cather and Company of Canada Limited and are referred to Geodetic datum.

SITE AND SOIL CONDITIONS

The bridge site is on the proposed ramp from Alta Vista to the Queensway in the southeast quadrant of the proposed reconstruction of the Alta Vista interchange. The area is generally flat with evidence of groundwater near the surface. The bridge site is near the edge of an existing ramp leading to the Queensway and boreholes 2 and 4 are on the side slopes of the embankment for the ramp.

The boreholes showed that the site is generally underlain by fill varying from 3 to 8 feet in depth, below the fill is a brown sandy silty clay till varying in thickness from 3 to 4.3 feet under the structure and 9 feet thick at borehole 5, 125 feet south of the structure. Grey shale bedrock is present beneath the till.

The fill is variable but is largely silty or sandy till like soil with inclusions of sand and organic debris and in places crushed stone near the surface. It exists in a loose to dense state. A thin layer of silt and peat in borehole 5 may be fill or the original ground surface.

The till is a mixture of sand silt and clay with some gravel and is in a dense condition. The elevation of its top surface varies little in the boreholes put down and in the boreholes under the structure its thickness is quite uniform varying from 3.0 to 4.3 feet.

The bedrock is a grey shale with nearly horizontal bedding planes. Approximately the upper foot is weathered and broken up, below that the shale is sound with a few well healed joints. Boreholes 1 to 4 under the proposed structure indicate the surface of the shale to be nearly horizontal at approximately elevation 187 in the area of the structure. The shale surface is about 6 feet lower at borehole 5.

GROUNDWATER CONDITIONS

Standpipes were installed in boreholes 1, 2 and 3 and a piezometer in borehole 4 to measure the water levels. Measurements taken within a few days of the installation indicate the groundwater level to be between 1.8 and 8.8 feet below the surface or from 2 to 7.5 feet above the top of the shale. It is therefore probable that water will be encountered in any excavation for foundations.

DISCUSSION

Because of the proximity of the shale bedrock at the location of the bridge it is recommended that the pier footings be founded directly on the shale bedrock. If the upper weathered portion of the shale is removed and clean sound shale exposed a bearing load of 10 tons/sq.ft. may be used. It may be more economical to support the abutments on piles to bedrock rather than on footings on the rock. In this case if 10 inch steel H piles are used and driven to practical refusal in the shale a load of 70 tons per pile may be used.

Excavation to sound shale and proper construction of the foundation will require the removal of groundwater during the process. This can probably best be accomplished by surrounding the footing area with a small ditch in the weathered shale leading to a sump in one corner from which the water can be pumped.

The till and overlying fill is suitable for supporting the approach embankments for the structure, however, a small amount of settlement under the weight of the additional fill is to be anticipated. To minimize differential settlement at the bridge structure, which will be on an unyielding foundation, it is recommended that the fill and any loose top portion of the till be removed for a distance from the structure equal to the height of the fill and that the slope of the excavation on the end opposite to the structure be not steeper than 3 horizontal to 1 vertical. The excavation should then be filled with good quality fill, equivalent to Department of Highways, Ontario Class B granular base course material, compacted in 6 inch layers to 95 percent standard (Proctor) compaction density.

F. A. DeLory

F. A. DeLory, P.Eng.

V. Milligan, P.Eng.

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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*

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. 64047

RECORD OF BOREHOLE 1

LOCATION See Figure 1 BORING DATE MAY 5-6, 1964 DATUM GEODETIC

BOREHOLE TYPE POWER AUGER & DIAMOND DRILLING BOREHOLE DIAMETER 4.5" & BXT CORE

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

ELEVN. / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS / FT.	ADDITIONAL LAB. TESTING
193.3	GROUND LEVEL				
0.0	LOOSE STONE AND SILTY SAND FILL, OCCASIONAL ORGANIC MATTER	1	2" D.O.	6	
		2	"	5	
190.1 / 3.2	DENSE SANDY SILTY TILL, SOME CLAY, SOME GRAVEL	3	"	41	MH
187.6 / 5.7	WEATHERED SHALE				
185.9 / 7.4	SOUND GREY SHALE BEDROCK BEDDING PLANES DIP AT 5° OR LESS	4	BXT R.C.	—	
		5	"	—	
176.5 / 16.8	END OF HOLE				

ELEVATION SCALE: 195, 190, 185, 180, 175

DYNAMIC PENETRATION RESISTANCE BLOWS / FT. 20 40 60 80 100

SHEAR STRENGTH C_u, LB./SQ.FT.

END OF PEN. TEST @ EL. 187.8
72 BLOWS FOR LAST 6 INCHES

CORE RECOVERY - PERCENT: 100 (sample 4), 100 (sample 5)

COEFFICIENT OF PERMEABILITY k, CM./SEC.

WATER CONTENT, PERCENT W_P W W_L — 5 10 15 20

PIEZOMETER OR STANDPIPE INSTALLATION:
GROUND LEVEL
CEMENT SEAL
PERFORATED PIPE
BENTONITE SEAL
SAND FILL

W.L. IN STANDPIPE @ EL. 192.2, MAY 7, 1964

15 – 5 – 10 Percent axial strain at failure

VERTICAL SCALE
1 INCH TO 5'-0"

GOLDER & ASSOCIATES

DRAWN J.A.
CHECKED E. D'L

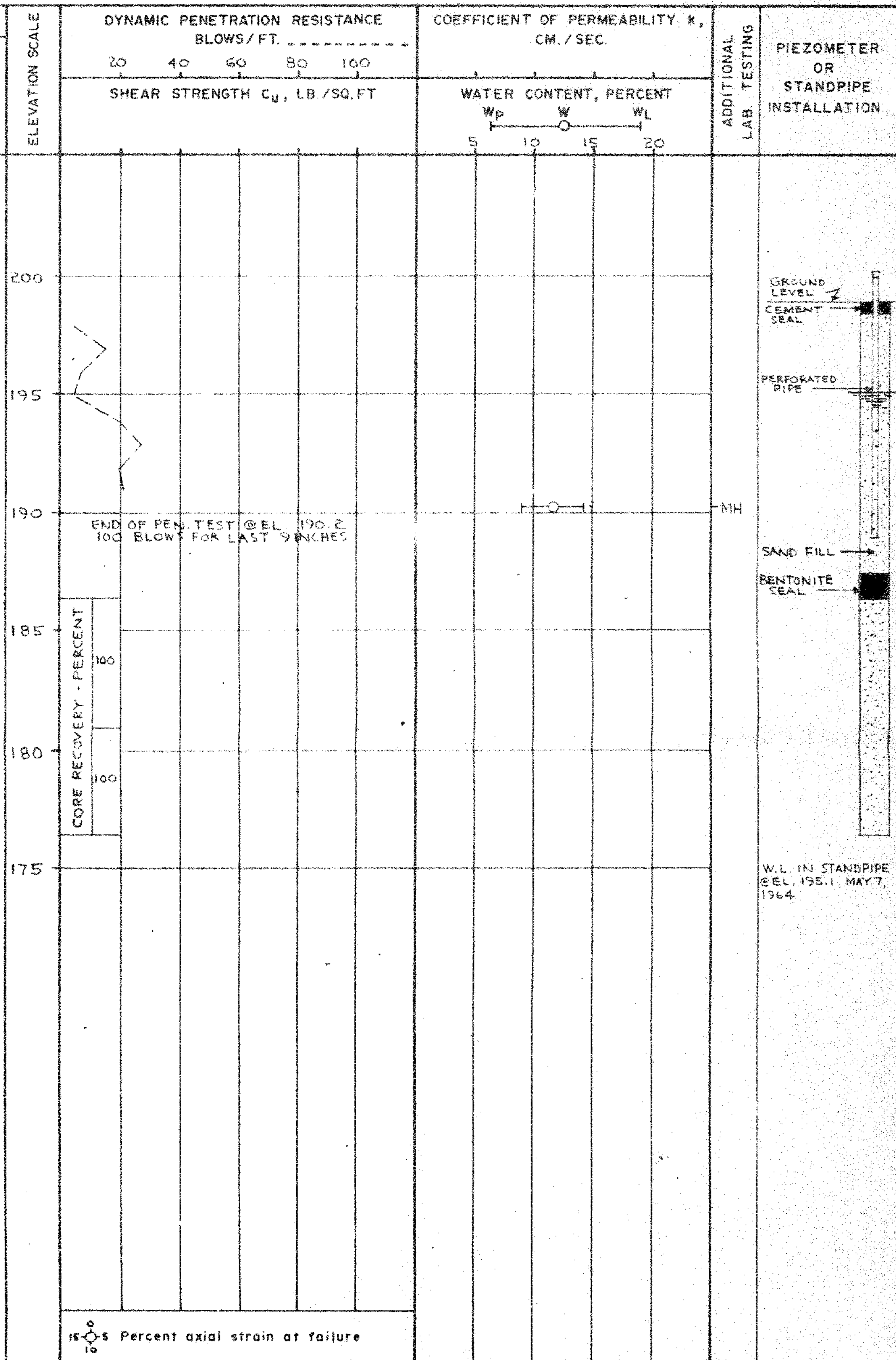
RECORD OF BOREHOLE 2

LOCATION See Figure 1 BORING DATE MAY 5-7, 1964 DATUM GEODETIC

BOREHOLE TYPE POWER AUGER & DIAMOND DRILLING BOREHOLE DIAMETER 4.5" & BXT CORE

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

ELEVN / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS/FT.
198.9	GROUND LEVEL			
0.0	LOOSE TO COMPACT SANDY CLAYEY SILT **FILL**, TRACE GRAVEL, OCCASIONAL SAND POCKETS, OCCASIONAL SMALL DEBRIS	1	2" D.O.	9
		2	"	28
191.9		3	"	12
7.0	COMPACT TO DENSE SANDY SILTY **TILL**, SOME CLAY, SOME GRAVEL	4	"	46
187.6		5	"	55
186.8	WEATHERED **SHALE**			
12.1	SOUND GREY SHALE **BEDROCK**, BEDDING PLANES DIP ~ 5°	6	BXT R.C.	—
176.4		7	"	—
22.5	END OF HOLE			



W.L. IN STANDPIPE @ EL. 195.1, MAY 7, 1964

15 -◇- 5 (0 / 10) Percent axial strain at failure

VERTICAL SCALE 1 INCH TO 5'-0"

GOLDER & ASSOCIATES

DRAWN J.A.

CHECKED F. DEL

RECORD OF BOREHOLE 3

LOCATION See Figure 1 | BORING DATE MAY 5-7, 1964 | DATUM GEODETIC

BOREHOLE TYPE POWER AUGER & DIAMOND DRILLING | BOREHOLE DIAMETER 4.5" & BXT CORE

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

SOIL PROFILE			SAMPLES				
ELEVN. / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	BLOWS / FT.	ELEVATION SCALE	ADDITIONAL LAB. TESTING
194.5	GROUND LEVEL					195	
0.0	LOOSE STONE TO SANDY SILT **FILL**, OCCASIONAL ORGANIC MATTER		1	2" D.O.	4		
			2	"	9		
191.6 / 2.9	COMPACT GREY-BROWN SANDY SILTY **TILL** SOME CLAY, SOME GRAVEL		3	"	19	190	MH
188.6 / 5.9	WEATHERED **SHALE**						
187.3 / 7.2	SOUND GREY SHALE **BEDROCK** BEDDING PLANES NEARLY HORIZONTAL		4	BXT R.C.	—	185	
			5	BXT R.C.	—	180	
176.6 / 17.9	END OF HOLE					175	

DYNAMIC PENETRATION RESISTANCE BLOWS/FT.

20 40 60 80 100

SHEAR STRENGTH C_u, LB./SQ.FT.

END OF PEN TEST @ EL. 188.6
70 BLOWS FOR LAST 6 INCHES

CORE RECOVERY - PERCENT

100

100

COEFFICIENT OF PERMEABILITY k, CM./SEC.

WATER CONTENT, PERCENT

W_P W W_L

5 10 15 20

PIEZOMETER OR STANDPIPE INSTALLATION

W.L. IN STANDPIPE @ EL. 190.7, MAY 7, 1964.

15 10 5 Percent axial strain at failure

VERTICAL SCALE
1 INCH TO 5'-0"

GOLDER & ASSOCIATES

DRAWN J.A.
CHECKED F. DEL.

PROJECT No. 64047

RECORD OF BOREHOLE 4

LOCATION See Figure 1 BORING DATE MAY 5-6, 1964 DATUM GEODETIC

BOREHOLE TYPE POWER AUGER & DIAMOND DRILLING BOREHOLE DIAMETER 4.5" & BXT CORE

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

ELEVN. DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS / FT.	CORE RECOVERY - PERCENT	WATER CONTENT, PERCENT	ADDITIONAL LAB. TESTING
198.3	GROUND LEVEL						
197.5 / 0.0 / 0.8	CRUSHED STONE **FILL**						
	LOOSE TO DENSE GREY-BROWN SANDY SILTY **FILL**, SOME CLAY, SOME GRAVEL	1	2" O.D.	10			
		2	"	20			
		3	"	34		~11	MH
190.3 / 8.0	DENSE GREY-BROWN SANDY SILTY **TILL**, SOME CLAY, SOME GRAVEL	4	"	55		~10 (W_P ~9, W_L ~14)	MH
		5	"	53			
187.3 / 186.5	WEATHERED **SHALE**						
11.8	SOUND GREY SHALE **BEDROCK**. A FEW HEALED FRACTURES, BEDDING PLANES DIP ~ 5°	6	BXT R.C.	—	100		
		7	"	—	98		
175.8 / 22.5	END OF HOLE						

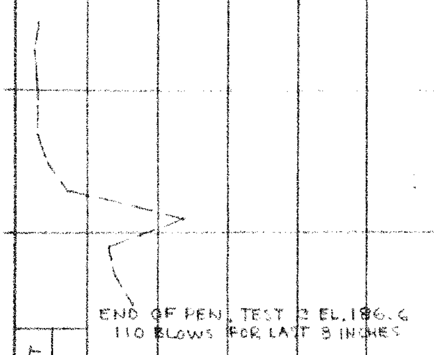
DYNAMIC PENETRATION RESISTANCE BLOWS/FT. (20 40 60 80 100)

SHEAR STRENGTH C_u, LB./SQ.FT.

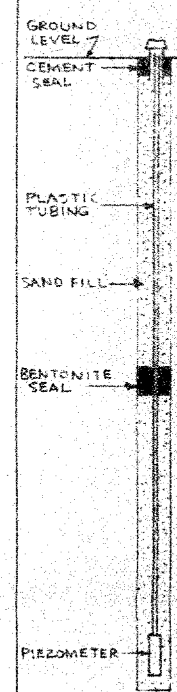
COEFFICIENT OF PERMEABILITY k, CM./SEC.

WATER CONTENT, PERCENT W_P — W — W_L (5 10 15 20)

ELEVATION SCALE: 200, 195, 190, 185, 180, 175



PIEZOMETER OR STANDPIPE INSTALLATION



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

VERTICAL SCALE 1 INCH TO 5'-0"

GOLDER & ASSOCIATES

DRAWN J.A.

CHECKED F.DEL

PROJECT No. [illegible]

RECORD OF BOREHOLE 5

LOCATION See Figure 1 BORING DATE MAY 5-6, 1964 DATUM GEODETIC

BOREHOLE TYPE POWER AUGER BORING BOREHOLE DIAMETER 4.5"

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

SOIL PROFILE ELEVN. / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	BLOWS/FT.	ELEVATION SCALE	ADDITIONAL LAB. TESTING
194.7	GROUND LEVEL					195	
0.0	LOOSE BROWN FINE TO COARSE SAND **FILL**, TRACE SILT, GRAVEL, CINDERS AND WOOD		1	2" D.O.	14		
191.7			2	"	10		
3.0	**SILT AND PEAT**						
3.5	DENSE TO VERY DENSE GREY SANDY SILTY **TILL**, SOME CLAY, SOME GRAVEL		3	"	20	190	
			4	"	16		MH
			5	"	40	185	
182.4							
12.3	END OF HOLE REFUSAL TO AUGERS **PROBABLY** SHALE **BEDROCK**					180	

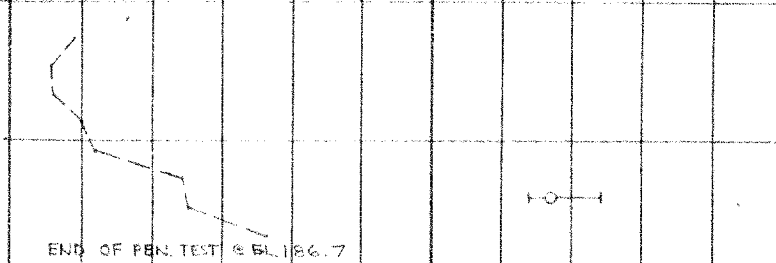
DYNAMIC PENETRATION RESISTANCE BLOWS/FT. (20, 40, 60, 80, 100)

SHEAR STRENGTH C_u, LB./SQ.FT.

COEFFICIENT OF PERMEABILITY k, CM./SEC.

WATER CONTENT, PERCENT W_p W W_L (5, 10, 15, 20)

PIEZOMETER OR STANDPIPE INSTALLATION



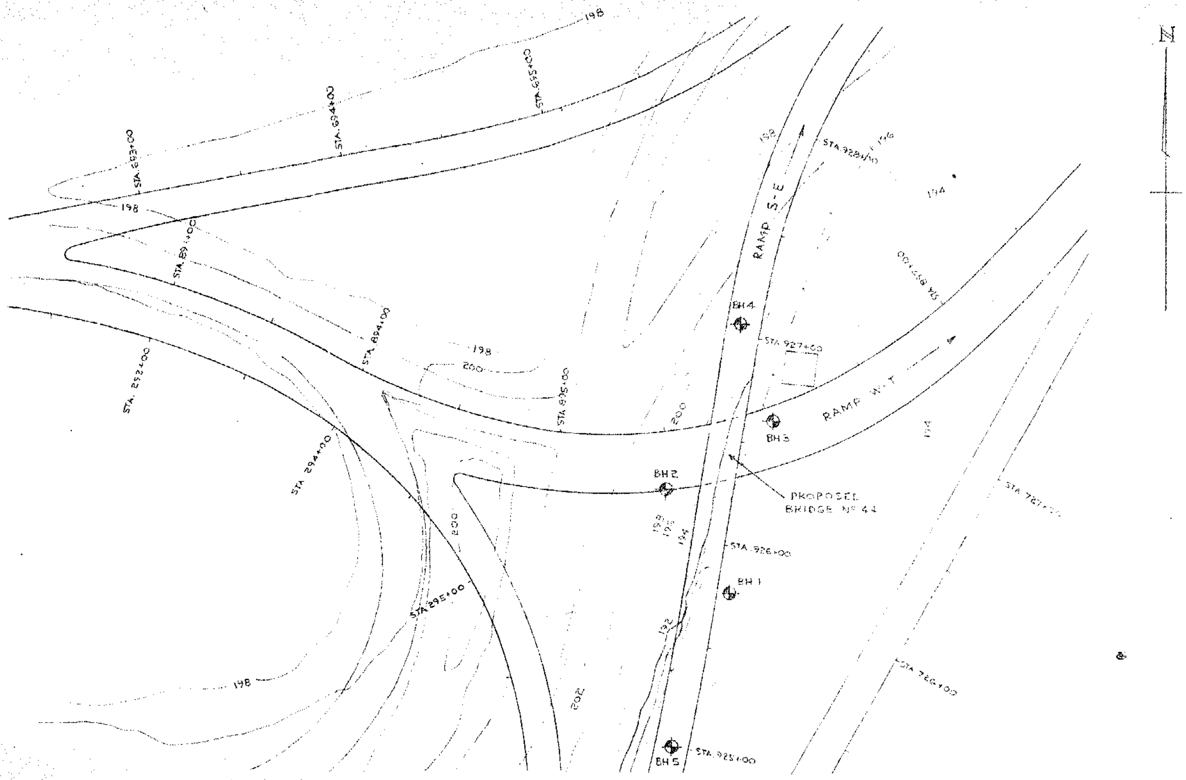
15-O-5 Percent axial strain at failure (10)

VERTICAL SCALE 1 INCH TO 5'-0"

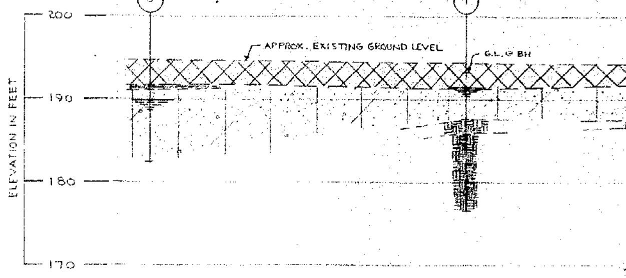
GOLDER & ASSOCIATES

DRAWN J.A.

CHECKED F. D'L



PLAN
SCALE: 1" TO 40'-0"

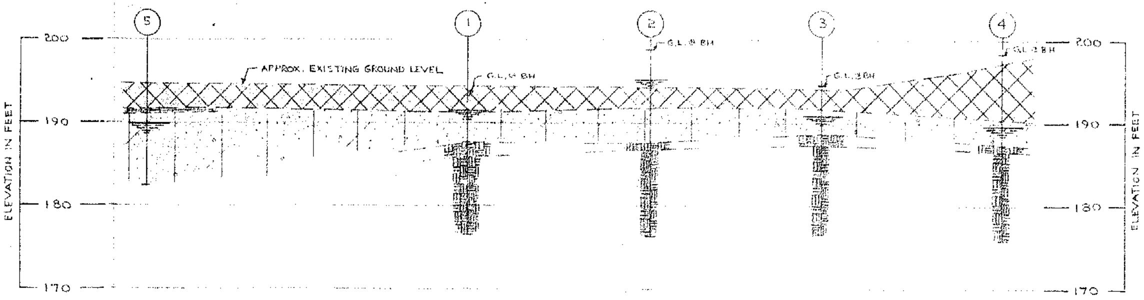


SCHEMATIC SECTION ALONG CEN
SCALE: HORIZ
VERT

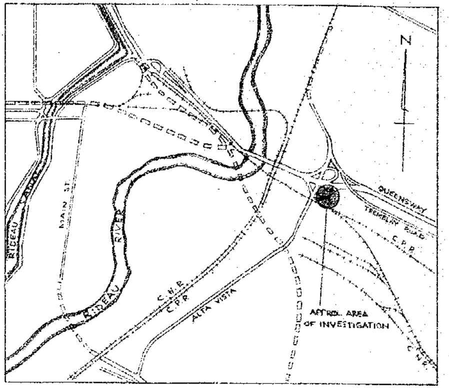
STRATIGRAPHY

- LOOSE TO DENSE SANDY SILTY **FILL**, SOME CRUSHED STONE, GRAVEL, CINDERS AND WOOD.
- COMPACT TO VERY DENSE SANDY SILTY **TILL**, SOME CLAY AND GRAVEL
- **SILT** AND **PEAT**
- WEATHERED AND FRACTURED **SHALE**
- SOUND GREY SHALE **BEDROCK**

BORING PLAN AND SOIL STRATIGRAPHY — FIGURE 1



SCHEMATIC SECTION ALONG CENTRELINE - PROPOSED RAMP S-E
SCALE: HORIZ. 1" TO 20'-0"
VERT. 1" TO 10'-0"



KEY PLAN
SCALE: 1" TO 2,200' (APPROX.)

STRATIGRAPHY

- LOOSE TO DENSE SANDY SILTY FILL, SOME CRUSHED STONE, GRAVEL, CINDERS AND WOOD.
- COMPACT TO VERY DENSE SANDY SILTY FILL, SOME CLAY AND GRAVEL
- SILT AND PEAT
- WEATHERED AND FRACTURED SHALE
- SOUND GREY SHALE BEDROCK

LEGEND

- BOREHOLE IN PLAN
- BOREHOLE IN ELEVATION
- W.L. IN BOREHOLE, MAY 7, 1964

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.

REFERENCE

PLAN SUPPLIED BY DE LEUW, CATHER & COMPANY OF CANADA LIMITED, DATED MAY 25, 1964.

STA. 727+00

GOLDER & ASSOCIATES

Made J.A.
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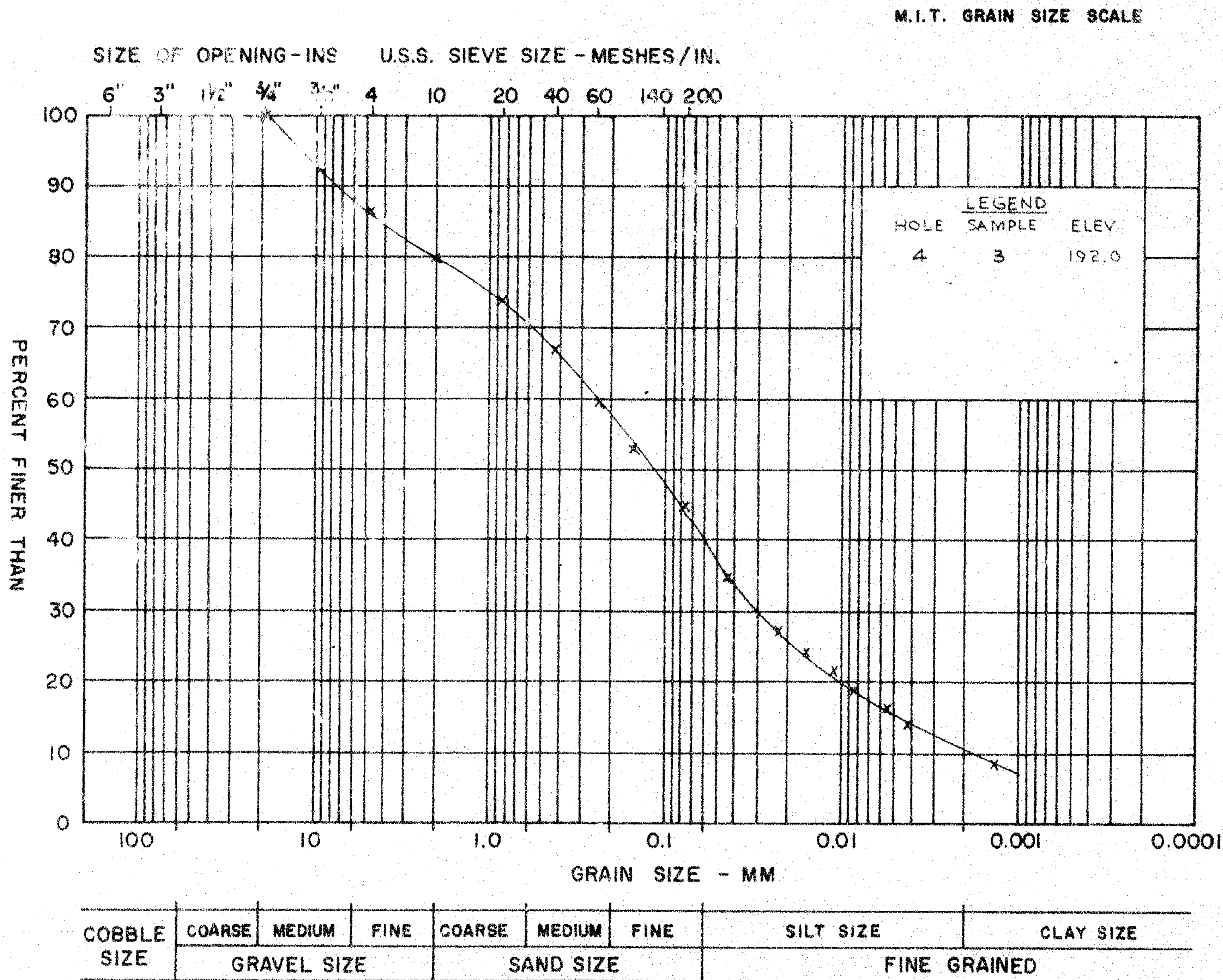

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GRAIN SIZE DISTRIBUTION

FILL

FIGURE 2

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GRAIN SIZE DISTRIBUTION

TILL

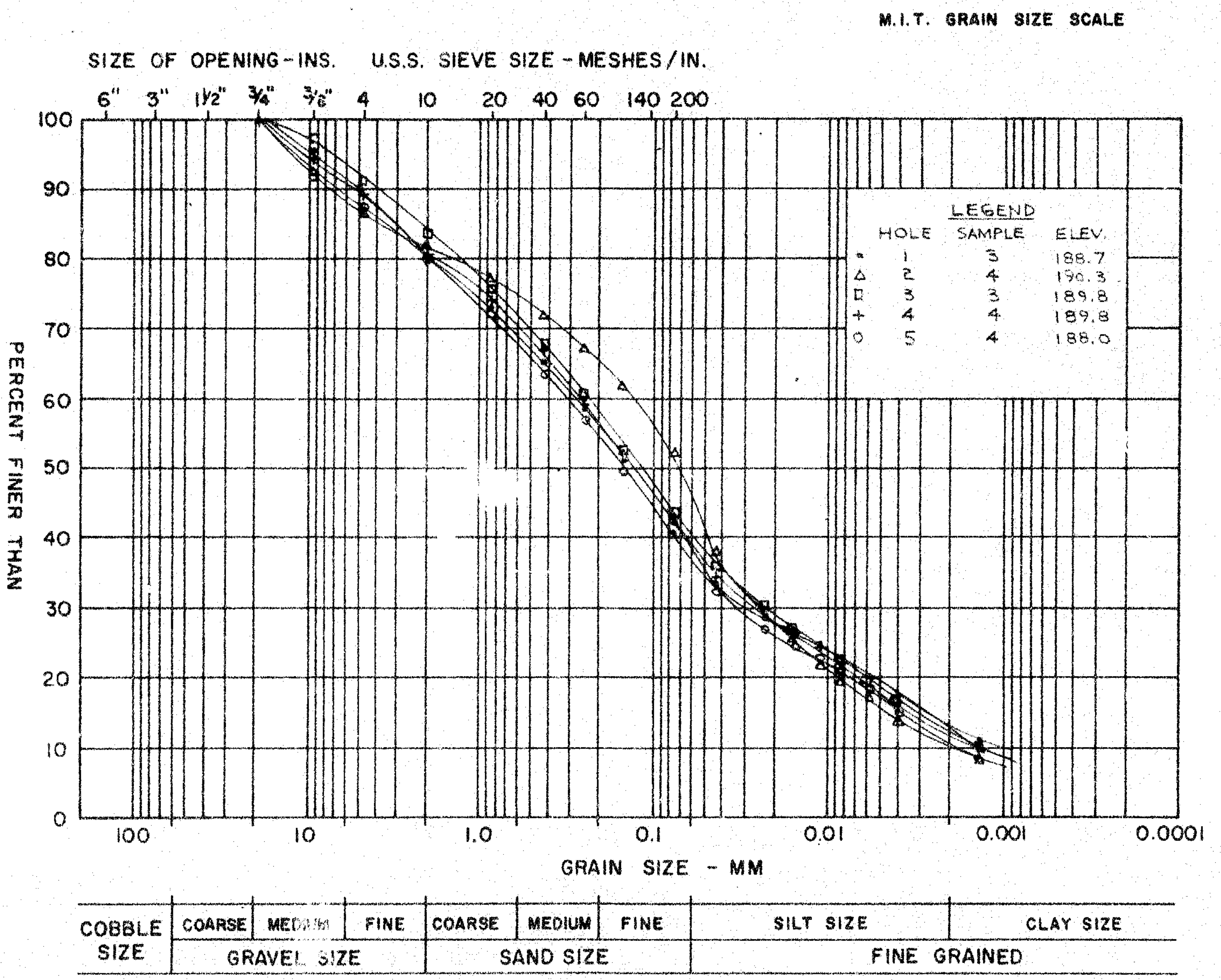

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FIGURE 3