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CORPORATION OF THE TOWN OF BURLINGTON

REPORT ON SUBSURFACE INVESTIGATION FOR PROPOSED NO.5 SIDE ROAD BRIDGE

BURLINGTON

ONTARIO

INTRODUCTION

At the request of the Engineering Department of the Town of Burlington we have carried out a soil investigation for the proposed bridge crossing at the above site. The purpose of the investigation was to determine the subsoil and groundwater conditions and to provide information regarding design and construction of the foundations for the proposed structure.

PROCEDURE

The field work for this investigation was carried out on April 26 and April 27, 1966 using a mobile power auger supplied and operated by the F.E. Johnston Drilling Company Limited. Two boreholes, numbered 1 and 2, were put down to a depth of about 35 feet; borehole 1 was accompanied by a dynamic cone penetration test. The groundwater level was observed by readings taken in piezometers installed in both of the boreholes. The field work was supervised throughout by a member of our engineering staff.

A detailed log for both borings is given on the Record of Borehole sheets following the text of this report. The locations of the borings together with a section of the inferred soil stratigraphy across the site are shown on Figure 1.

The samples obtained during the investigation were brought to our laboratory for detailed examination and testing. The results of the laboratory tests are shown on the Record of Borehole sheets and on Figures 2 and 3.

All elevations given in this report are referred to a local bench mark consisting of the top of a survey stake nailed to the telephone pole located on the south side of No. 5 Side Road, some 100 feet east of the existing bridge. The elevation of this bench mark is given as 99.78 assumed datum; it is understood that this corresponds to elevation 594.74 Geodetic datum.

SITE AND GEOLOGY

The site under investigation is located at the proposed re-aligned intersection of No. 5 Side Road and the Bell School Line in the Town of Burlington, Ontario. The area is generally flat lying to gently undulating. A relatively shallow, narrow tributary of Bronte Creek presently flows under the existing bridge structure. The water level in this stream, at the time of the investigation, was at about

elevation 94 while the maximum water depth was some 3 to 4 feet. No. 5 Side Road is a gravel roadway super-elevated some 5 to 6 feet above the surrounding terrain at about elevation 99.

From available geological information it is known that the area is within the physiographic region known as the Peel Plain, the overburden of which is generally a glacial till deposit comprised basically of clay soils containing shale and limestone fragments. Bedrock consisting of red shale of the Queenston formation, Ordovician Period underlies the site.

SUBSOIL CONDITIONS

The detailed stratigraphy encountered in the borings is given on the Record of Borehole sheets and on Figure 1. Following is a summarized account of the soil conditions inferred from the borings.

The borings were put down through the roadway embankment fill. This fill, which is some 6 to 7 feet thick, consists of a stiff to hard brown clayey silt with some sand and a trace of gravel. At borehole 1 a layer of wood chips some 2 feet thick was encountered below about elevation 95. Two typical grading curves of the fill are shown on Figure 2.

Directly underlying the fill, at about elevation 92, is the predominant overburden stratum across the site consisting of a brown clayey silt to silty clay, with some sand and a trace of gravel. This stratum extends to the maximum depth of exploration, about 40 feet. The stratum above about elevation 85 is desiccated and mottled brown in colour, below this depth it becomes grey brown. It is considered that the clayey silt stratum is a till. Two typical grading curves carried out on samples from the clayey silt, are shown on Figure 3. A layer of silt some 5 feet thick was encountered within the stratum at borehole 2, a grading curve for a sample of this layer is also shown on Figure 3.

Three Atterberg limit tests carried out on samples of the clayey silt till indicate that the material is of low plasticity, with the corresponding natural water content ranging from about the plastic limit to about 5 percent below the plastic limit.

Standard penetration tests, the results of which are plotted on the Record of Borehole sheets, were carried out within the stratum. The results of the tests show that the "N" values range from 35 blows/ft. to greater than 100 blows/ft. being typically about 50 blows/ft. Based on the "N" values it is considered that the consistency of the stratum is hard.

GROUNDWATER CONDITIONS

The groundwater conditions at the site were determined during and following the period of the investigation by readings taken in the two piezometers installed in the borings. The final set of readings in the piezometers was made on May 9, 1966. At borehole 1 the piezometric groundwater level was some 2 feet below ground surface at about elevation 97. A slight artesian pressure (about $\frac{1}{2}$ foot above ground surface) was encountered at borehole 2 where the water overflowed the piezometer tubing at about elevation 99.

DISCUSSION

It is understood that the proposed bridge is to be located near the re-aligned intersection of No. 5 Side Road and Bell School Line and some 50 to 60 feet east of an existing bridge. The proposed bridge is to be a rigid reinforced concrete frame structure with a plan area about 28 feet by 31 feet. It is understood that the roadway at the proposed bridge is to be about 30 feet wide and that the maximum road grade will be about elevation 100.

The locations of the existing bridge, proposed bridge structure and the proposed stream diversion are shown in plan on Figure 1.

Foundations

The borings put down in this investigation indicate that the significant foundation subsoil at the site is the hard clayey silt till stratum encountered at about elevation 92. The subsoil conditions are considered suitable for spread footing foundation support for the rigid frame bridge structure and associated wing walls. For frost protection, it is recommended that the underside of all foundations be provided with at least 4 feet of earth cover below the proposed stream bed elevation of 93. This would place the foundations below about elevation 89. An average "N" value of 50 blows/ft. was obtained at and below foundation level during sampling in the boreholes. Based on this value it is considered that an allowable bearing value of 4 tons/sq.ft. may be used for footing design. With this allowable bearing value it is considered, that settlement of foundations under load will be minor, probably less than $\frac{1}{2}$ inch, provided softening of the subsoil is prevented at and below foundation level as discussed below.

In computation of sliding resistance between a rough concrete footing and the undisturbed clayey silt till subsoil, a coefficient of friction of 0.35, which is a limiting value, may be used.

The backfill to the abutments and wing walls should be comprised of properly compacted free draining non-frost-susceptible granular material. This granular backfill should extend for at least a horizontal distance of 4 feet behind the sides and wing walls and provision for drainage from the backfill should be made.

With full effective drainage of the granular backfill, the rigid structure abutments should be designed using an "at-rest" earth pressure coefficient, K_o , of 0.5.

Rip-rap should be placed in the bottom of the stream channel, and on the embankment side slopes in the vicinity of the bridge to prevent scour.

Construction Procedures

It would be advantageous to carry out the excavation at the proposed bridge structure in the dry and for this reason it is recommended that the bridge construction be carried out prior to diversion of the stream.

At the location of the proposed structure excavation will take place through the clayey silt embankment fill and into the residual hard clayey silt till stratum to reach foundation level (at about elevation 89). The results of this investigation indicate

that this excavation will be carried out some 10 feet below the measured piezometric groundwater level. Because of the relatively impermeable nature of the clayey silt till groundwater seepage into excavations should be minor and should be readily handled by pumping from properly installed and maintained sumps.

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

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BTD:hdg
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May 19, 1966.

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	<i>N</i> , 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	<i>c_u</i> , 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

<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 = $c_v t / d^2$ (d , drainage path)
U	degree of consolidation

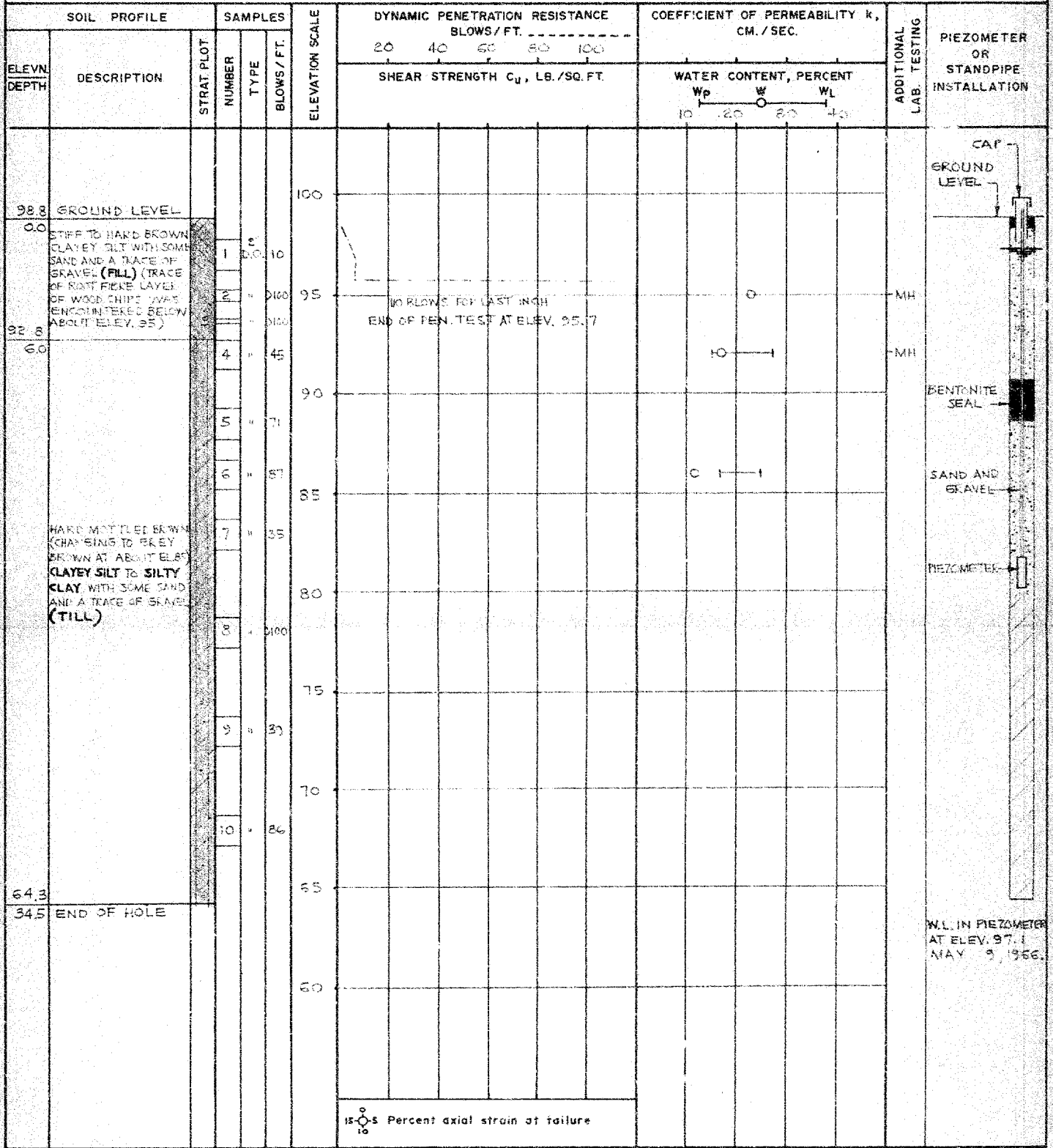
(e) Shear strength

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_r	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.

RECORD OF BOREHOLE 1

LOCATION See Figure 1 BORING DATE APRIL 26, 1966 DATUM LOCAL
 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



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DRAWN *in w*
 CHECKED *BTD*

RECORD OF BOREHOLE 2

LOCATION See Figure 1 BORING DATE APRIL 27, 1966 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

SOIL PROFILE		SAMPLES			ELEVATION SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FT. -----		COEFFICIENT OF PERMEABILITY k, CM./SEC.		ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
ELEV. DEPTH	DESCRIPTION	STRAT. PLAT	NUMBER	TYPE		BLOWS/FT.	SHEAR STRENGTH C_u , LB./SQ. FT.	WATER CONTENT, PERCENT			
								W_p	W W_L		
							10	20	30	40	
99.2	GROUND LEVEL					100					GROUND LEVEL
0.0	STIFF DARK BROWN CLAYEY SILT WITH SOME SAND AND A TRACE OF GRAVEL (FILL)		1	2"	10						
			2	"	14	95					MH
			3	"	13						
31.7			4	"	65	90					
1.5			5	"	75						MH
	HARD MOTTLED BROWN (CHANGING TO GREY- BROWN AT AN EL. 55) CLAYEY SILT TO SILTY CLAY WITH SOME SAND AND A TRACE OF GRAVEL (MIL) (A LAYER OF SILT WITH SOME SAND AND A TRACE OF CLAY AND GRAVEL ABOUT 5 FEET THICK ENCOUNTERED BELOW ABOUT EL. 55)		6	"	43						SAND AND GRAVEL
			7	"	90						MH
			8	"	41						
					75						
					60						
					50						
59.2					40						PIEZOMETER
40.0	END OF HOLE										W.L. IN PIEZOMETER AT ELEV. 99.7 MAY 9, 1966
						15-0-5 Percent axial strain at failure					

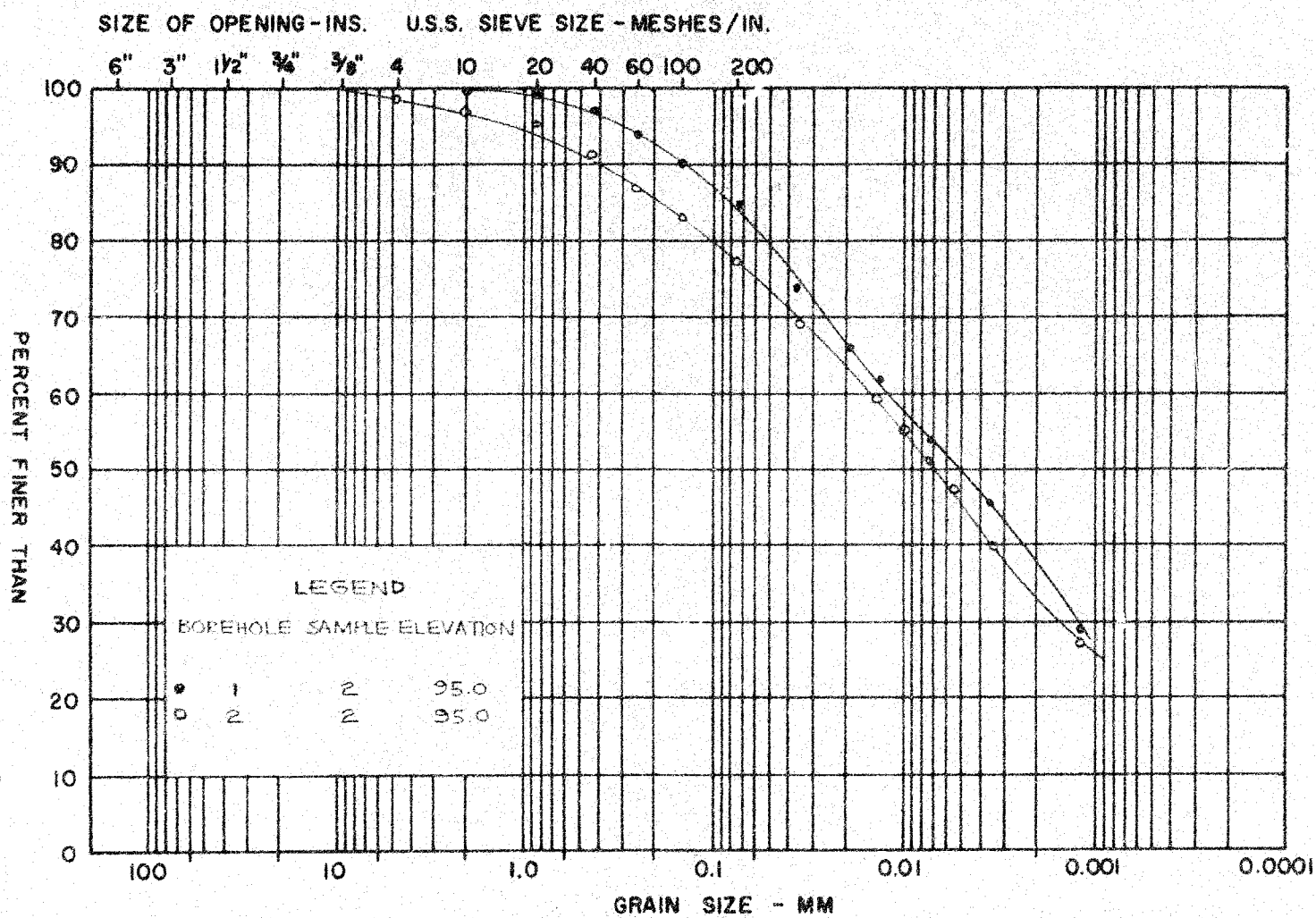
15-10-5 Percent axial strain at failure

VERTICAL SCALE
1 INCH TO 5' - 0"

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DRAWN *M.W.*
CHECKED *R.T.D.*

M.I.T. GRAIN SIZE SCALE



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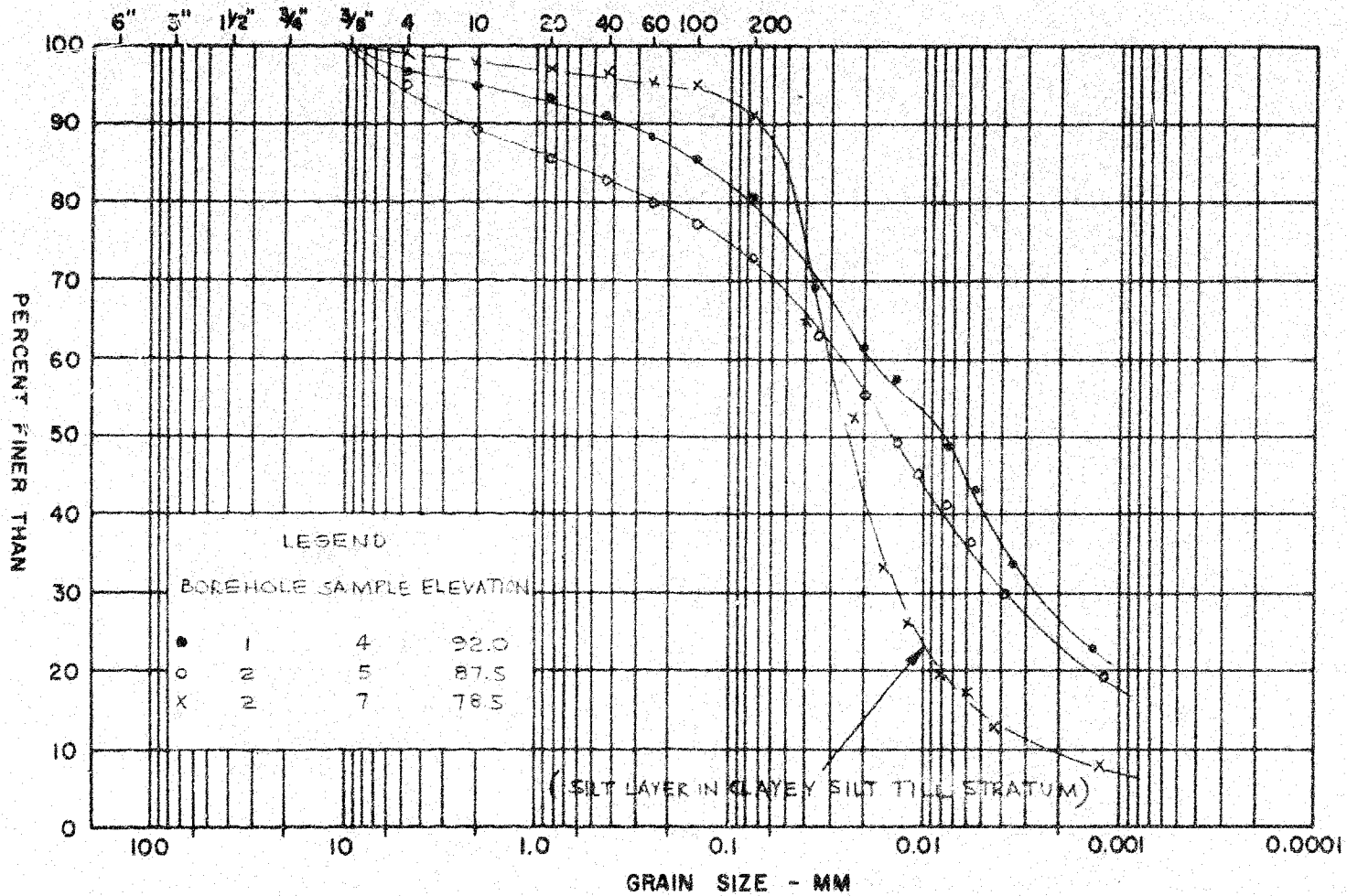
GRAIN SIZE DISTRIBUTION
CLAYEY SILT (FILL)

FIGURE 2

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

M.I.T. GRAIN SIZE SCALE

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



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GRAIN SIZE DISTRIBUTION
CLAYEY SILT (MLL)

FIGURE

(1)

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