

CONT. 70 - 232

HWY. 417

TWP. OF CAMBRIDGE

31G - 44

## MEMORANDUM

70-232

316-44

To: Mr. J. E. Gruspier,  
Regional Materials Engineer,  
EASTERN REGION, Kingston, Ont.

FROM: Foundation Section,  
Materials & Testing Office,  
Room 107, Lab. Bldg.

ATTENTION:

DATE: May 1, 1970

OUR FILE REF.

IN REPLY TO

MAY 7 1970

SUBJECT:

## FOUNDATION INVESTIGATION REPORT

For

Proposed Gully Crossings  
Hwy. #417 - East- and Westbound Lanes  
Twp. of Cambridge - Co. of Russell  
District No. 9 (Ottawa)  
W.J. 70-F-22 -- W.P. 35-66-03,04

CONT. 70-232

1. INTRODUCTION:

At a meeting held in Kingston on March 13, 1970, Mr. J. E. Gruspier, Regional Materials Engineer (Eastern Region) requested the Foundation Section to assess the magnitude of anticipated settlements beneath fills which will carry the East- and Westbound lanes of proposed Hwy. #417 across gullies at two separate sites near Casselman. Subsequently, a subsurface investigation, consisting of one borehole and two dynamic cone penetration tests, was carried out by this Section. The results of this investigation are presented in this memo, together with our estimates of the anticipated settlements beneath the proposed fills at the gully crossings.

2. SITE AND SUBSOIL CONDITIONS:

The gully crossings are located at two separate sites, one about 0.5 miles north of County Rd. #3 (Site #1), and the other between County Rd. #3 and the South Nation River (Site #2).

2. SITE AND SUBSOIL CONDITIONS: (cont'd.) ...

Site #1 is located in Lot 19, Concession V, some 3.5 miles west of the Town of Casselman. At this site, the centre-lines of the Eastbound and Westbound lanes are situated about 250 ft. apart. The average ground surface elevation in the area is about 218<sup>+</sup>. The gully at the E.B.L. and W.B.L. crossings is about 7 to 12 ft. deep. Generally swampy conditions prevail in the area of the proposed W.B.L. gully crossing.

Site #2 is located in Lots 15 and 16, Concession VI, some 1.5 miles southwest of Casselman. At this site, the Eastbound and Westbound lane centre-lines of the proposed Hwy. #417 are situated about 500 ft. apart. The average ground surface elevation in this area is about 211<sup>+</sup> and the gullies are 6 to 12 ft. deep.

The subsoil at these sites consists of a surficial layer of topsoil followed by about 70 ft. of silty clay to clay of marine origin (Leda clay). The clay deposit contains occasional silt and fine sand seams and is generally grey in colour with some black mottling and grey-brown layering. Field vane tests in this deposit at Site #1 indicate that the consistency of the deposit to a depth of about 35 ft. below the ground surface, ranges from soft to firm ( $C_u = 400$  to 800 p.s.f.). One consolidation test on a sample from Site #1 indicates that the deposit has been preconsolidated to a pressure of about 1000 p.s.f. in excess of the existing effective overburden pressure. The results of Atterberg limit tests are shown on Figure 1 in the Appendix. The consolidation test e-log p curve is shown on Figure 2.

Based on the results of the dynamic cone penetration tests, as well as our past experience in this area, it is inferred that the clay deposit is followed, at about elevation 135, by a relatively incompressible (probably glacial till) deposit.

2. SITE AND SUBSOIL CONDITIONS: (cont'd.) ...

At the time of this investigation the water levels in the open boreholes at Site #1 and Site #2 were, respectively, at elevations 208.4 and 203.3. These water levels are slightly above the creek water level in the respective gullies.

3. DISCUSSION AND RECOMMENDATIONS:

It is proposed to carry the East- and Westbound Lanes of Hwy. #417 over 6 to 12 ft. deep gullies. The following Table gives all the known pertinent details regarding these proposed crossings:

<u>Site #1</u>	<u>Location of Gully</u>	<u>Elevation Gully Bottom</u>	<u>Proposed Profile Grade</u>	<u>Max.Ht. of Fill (ft.)</u>
E.B.L.	Sta. 212+50 - 213+75	210 <sup>+</sup> <sub>-</sub>	223 <sup>+</sup> <sub>-</sub> 221	14 <sup>+</sup> <sub>-</sub>
W.B.L.	Sta. 213+85 - 215+60	207 <sup>+</sup> <sub>-</sub>	223 <sup>+</sup> <sub>-</sub> 221	16 <sup>+</sup> <sub>-</sub>
<u>Site #2</u>				
E.B.L.	Sta. 330+00 - 332+85	197 <sup>+</sup> <sub>-</sub>	213 <sup>+</sup> <sub>-</sub> 211	16 <sup>+</sup> <sub>-</sub>
	Sta. 333+60 - 334+85	200 <sup>+</sup> <sub>-</sub>	213 <sup>+</sup> <sub>-</sub>	13 <sup>+</sup> <sub>-</sub>
W.B.L.	Sta. 321+35 - 324+00	204 <sup>+</sup> <sub>-</sub>	215 <sup>+</sup> <sub>-</sub> 214	11 <sup>+</sup> <sub>-</sub>
	Sta. 324+40 - 326+00	206	215 <sup>+</sup> <sub>-</sub> 214	9 <sup>+</sup> <sub>-</sub>

As of this writing, details regarding the proposed culvert sizes, alignment, and invert elevations at the various gully crossings, are not known. It is likely, however, that as a result of culvert placement beneath the fills, the surcharge loading will be lower than that which would occur beneath the fill heights indicated on the preceding Table.

The investigation has revealed that the two sites are underlain by some 70 ft. of slightly preconsolidated, soft to firm, sensitive silty clay to clay, followed at about elevation 135, by a relatively incompressible deposit (probably glacial till).

3. DISCUSSION AND RECOMMENDATIONS: (cont'd.) ...

Stability problems are not anticipated with standard 2:1 slopes for embankments constructed to the proposed profile grade.

In order to minimize settlements due to consolidation of the clay deposit, it is recommended that the fill heights should be restricted such that the induced vertical stresses beneath the fills do not exceed the preconsolidation pressure. For example, if fill heights are restricted to 8 ft. (at or below preconsolidation pressure), it is estimated that settlements of in the order of 6 to 8 inches will be realized during or immediately after construction due to the elastic recompression of the clay deposit. However, for fills in excess of preconsolidation pressure, the settlements will be well in excess of the aforementioned value. For example, for a 12-ft. high embankment, the anticipated settlement, due to consolidation of the underlying clay deposit, will be in the order of 20 inches. Time-rate of settlement analyses indicate that of the total settlement anticipated at the proposed gully crossings, about 25 per cent should be realized within a period of 2 years, 50 per cent within a period of 5 years, and the remainder in an additional 8 to 10 year period.

In view of the foregoing, we feel that it would be desirable to adopt as low a profile grade as is permissible at these proposed crossings, as well as to delay the final paving operations for as long a period as possible after construction of the fills.

If any of the foregoing needs clarification, or if we can be of any further help, please call us.

CM/MdeP

cc: Messrs. J. E. Grusnier (2)  
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For:  
A. G. Stermac  
PRINCIPAL FOUNDATION ENGR.

Foundations Files  
Gen. Files

DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

## RECORD OF BOREHOLE SITE No. 1

FOUNDATION SECTION

JOB	70-F-22	LOCATION	Sta. 213 + 10 @ E.B.L. Hwy. 417	ORIGINATED BY	HRS
W.P.	35-66-03 & 04	BORING DATE	March 17, 19, 1970	COMPILED BY	HRS
DATUM	Geodetic	BOREHOLE TYPE	Washboring-NK Casing; Cone	CHECKED BY	

[illegible]

DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

## RECORD OF BOREHOLE SITE No.2

FOUNDATION SECTION

JOB 70-F-22

LOCATION

Sta. 323 + 00 @ W.B.L. Hwy. 417

ORIGINATED BY

HRS

W.P. 35-66-03 &amp; 04

BORING DATE

March 19 &amp; 20, 1970

COMPILED BY

HRS

DATUM Geodetic

BOREHOLE TYPE

Dynamic Cone Test

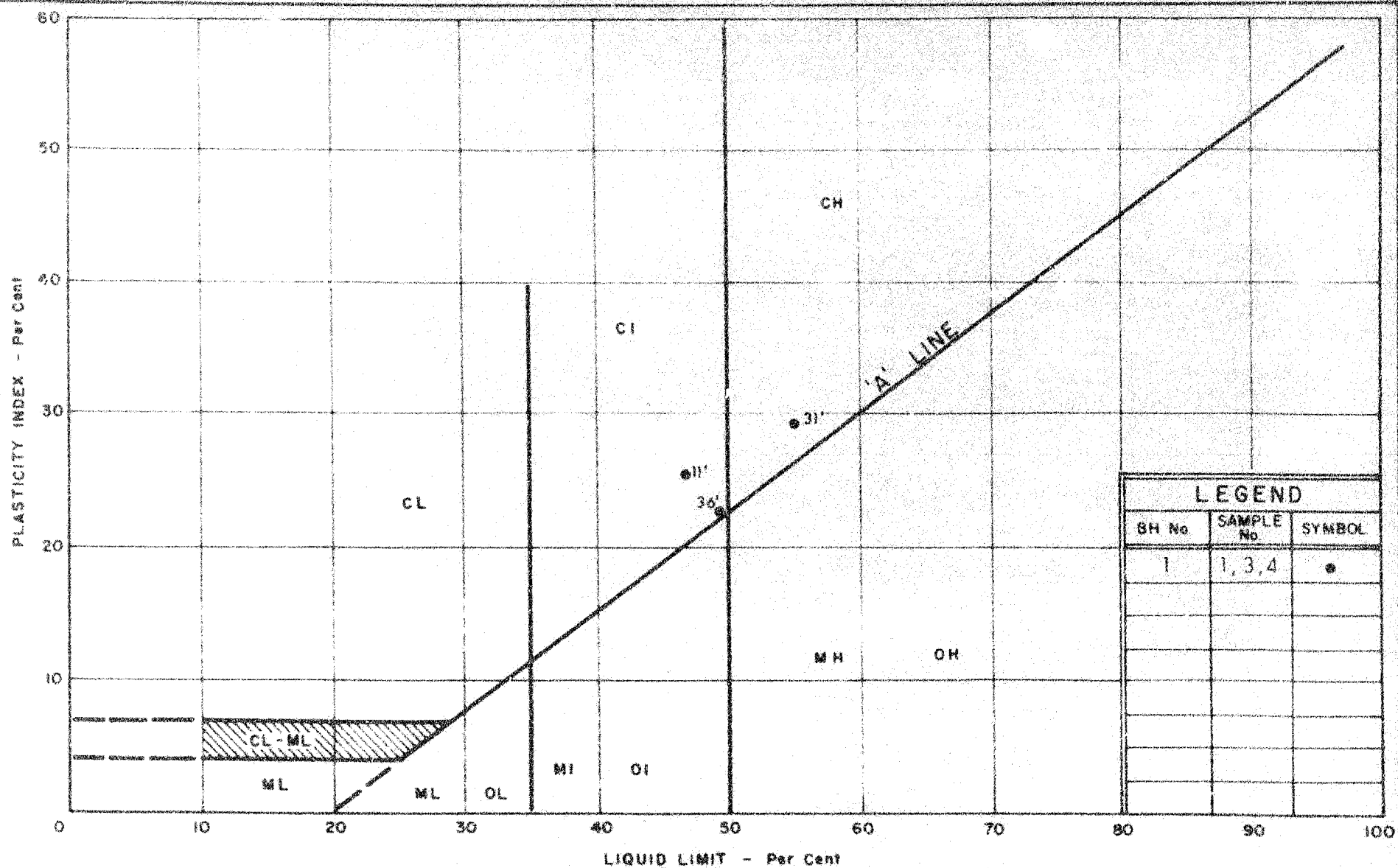
CHECKED BY

HRS

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT — $w_L$ PLASTIC LIMIT — $w_p$ WATER CONTENT — $w$			BULK DENSITY $\gamma$ P.C.F.	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		20	40	60	80	100	SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE					WATER CONTENT % $w_p$ — $w$ — $w_L$
206.8 0.0	Ground Level																
	Probably Clay																
135.8 69.0	Probably Glacial Till																
118.0	End of Cone Test Probably Bedrock																Practical refusal

20  
10 → 5 % STRAIN AT FAILURE  
10





DEPARTMENT OF HIGHWAYS  
MATERIALS and  
TESTING  
DIVISION

# PLASTICITY CHART SILTY CLAY - CLAY

WP No. 35-66-03 & -04

JOB No. 70-F-22

FIG. No. 1



# VOID RATIO vs PRESSURE

JOB 70 E-22

$W_L = 55 \%$

$W_p = 79 \%$

$W = 58 \%$

$C_c = 1.000$

BORE HOLE SITE No 1

SAMPLE 3

DEPTH 31'

ELEV. 179.6

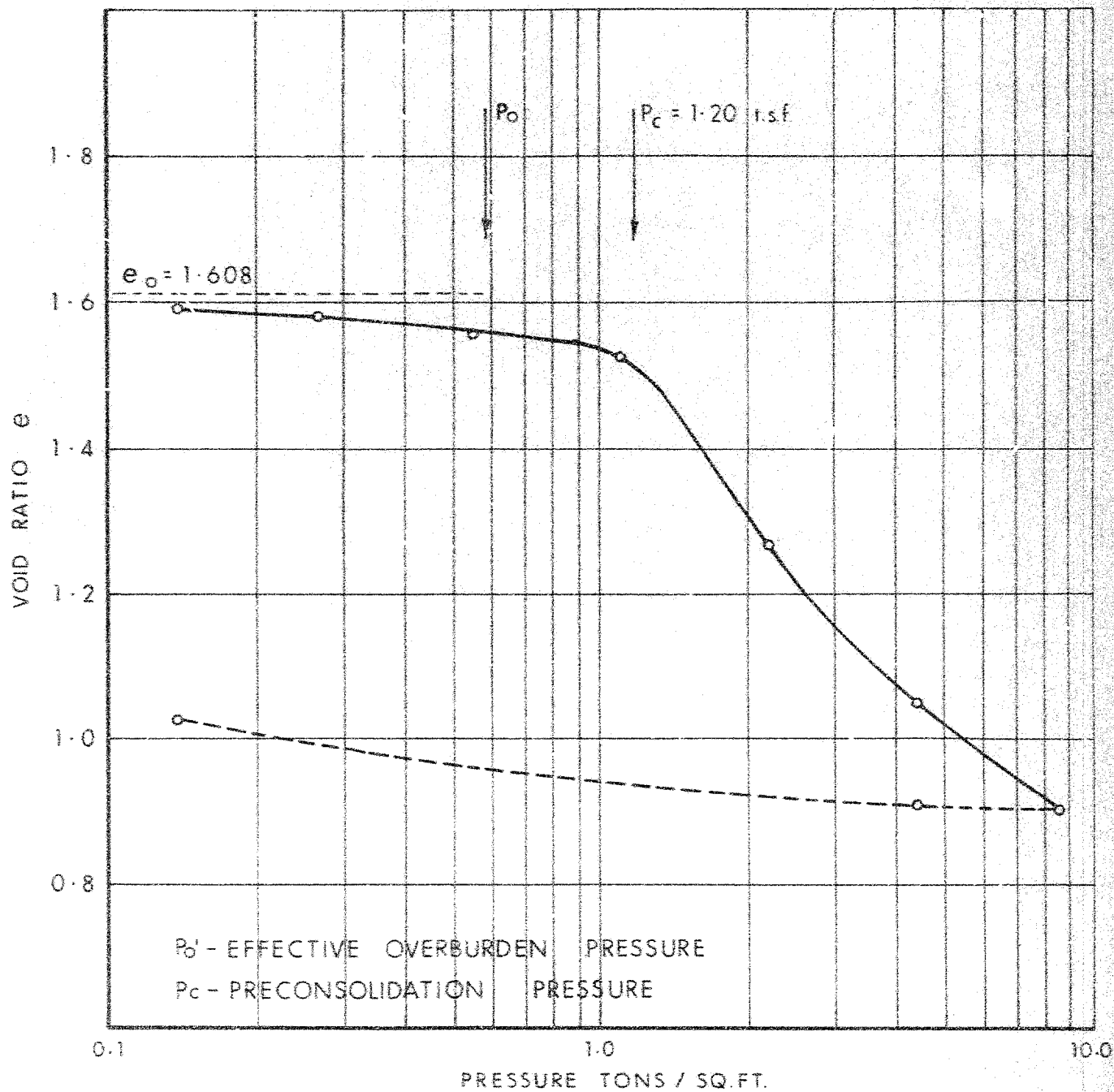


FIG. 2

## ABBREVIATIONS USED IN THIS REPORT

### PENETRATION RESISTANCE

STANDARD PENETRATION RESISTANCE 'N' - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE - THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL, THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW.

### DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS:-

<u>CONSISTENCY</u>	<u>'N' BLOWS/FT.</u>	<u>c LB./SQ. FT.</u>	<u>DENSENESS</u>	<u>'N' BLOWS/FT.</u>
VERY SOFT	0 - 2	0 - 250	VERY LOOSE	0 - 4
SOFT	2 - 4	250 - 500	LOOSE	4 - 10
FIRM	4 - 8	500 - 1000	COMPACT	10 - 30
STIFF	8 - 15	1000 - 2000	DENSE	30 - 50
VERY STIFF	15 - 30	2000 - 4000	VERY DENSE	> 50
HARD	> 30	> 4000		

### TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.B.	SCRAPER BUCKET SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE
S.T.	SLOTTED TUBE SAMPLE		
	P.H. SAMPLE ADVANCED HYDRAULICALLY		
	P.M. SAMPLE ADVANCED MANUALLY		

### SOIL TESTS

Q <sub>u</sub>	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
Q	UNDRAINED TRIAXIAL	F.V.	FIELD VANE
Q <sub>cu</sub>	CONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
Q <sub>d</sub>	DRAINED TRIAXIAL	S	SENSITIVITY

## ABBREVIATIONS USED IN THIS REPORT

### SOIL PROPERTIES

$\gamma$	UNIT WEIGHT OF SOIL (BULK DENSITY)
$\gamma_s$	UNIT WEIGHT OF SOLID PARTICLES
$\gamma_w$	UNIT WEIGHT OF WATER
$\gamma_d$	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
$\gamma'$	UNIT WEIGHT OF SUBMERGED SOIL
G	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
e	VOID RATIO
n	POROSITY
w	WATER CONTENT
$S_r$	DEGREE OF SATURATION
$w_L$	LIQUID LIMIT
$w_p$	PLASTIC LIMIT
$I_p$	PLASTICITY INDEX
s	SHRINKAGE LIMIT
$I_L$	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
$I_C$	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
$e_{max}$	VOID RATIO IN LOOSEST STATE
$e_{min}$	VOID RATIO IN DENSEST STATE
$I_D$	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY $D_r$ IS ALSO USED
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
$m_v$	COEFFICIENT OF VOLUME CHANGE = $\frac{-\Delta e}{(1+e)\Delta\sigma}$
$C_r$	COEFFICIENT OF CONSOLIDATION
$C_c$	COMPRESSION INDEX = $\frac{\Delta e}{\Delta \log_{10} \sigma}$
$T_v$	TIME FACTOR = $\frac{c_v t}{d^2}$ (d, DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
$T_f$	SHEAR STRENGTH
$c'$	EFFECTIVE COHESION
	INTERCEPT
$\phi'$	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
	IN TERMS OF EFFECTIVE STRESS $T_f = c' + \sigma' \tan \phi'$
$c_u$	APPARENT COHESION
$\phi_u$	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
	IN TERMS OF TOTAL STRESS $T_f = c_u + \sigma \tan \phi$
$\mu$	COEFFICIENT OF FRICTION
$S_t$	SENSITIVITY

### 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

### STRESS AND STRAIN

u	PORE PRESSURE
$\sigma$	NORMAL STRESS
$\bar{\sigma}$	NORMAL EFFECTIVE STRESS ( $\bar{\sigma}$ IS ALSO USED)
$\tau$	SHEAR STRESS
$\epsilon$	LINEAR STRAIN
$\gamma$	SHEAR STRAIN
$\nu$	POISSON'S RATIO ( $\mu$ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNGE'S MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
$\eta$	COEFFICIENT OF VISCOSITY

### EARTH PRESSURE

d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
$\delta$	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
$K_0$	COEFFICIENT OF EARTH PRESSURE AT REST

### FOUNDATIONS

B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY, DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY
$k_s$	MODULUS OF SUBGRADE REACTION

### SLOPES

H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
$\beta$	ANGLE OF SLOPE TO HORIZONTAL