

## MEMORANDUM

To: Mr. B. R. Davis,  
Bridge Engineer,  
Bridge Division,  
Admin. Bldg.

From: Foundation Section,  
Materials & Testing Div.,  
Room 107, Lab. Bldg.

Attention: Mr. S. McCombie

Date: April 25, 1968

Our File Ref.

In Reply To

## SUBJECT

## FOUNDATION INVESTIGATION REPORT

For

Proposed Extension to the  
Existing Structure at the Crossing  
Of Highways 35 & 115 and Highway 2  
County of Durham, Township of Clarke  
District No. 7 (Port Hope)  
H.J. 58-P-21 -- H.P. 199-65-0

Attached, we are forwarding to you, our detailed  
foundation investigation report on the subsoil conditions  
existing at the above structure site.

We believe that the factual data and recommendations  
contained therein, will prove adequate for your design  
requirements. Should additional information be required,  
please feel free to contact our Office.

AGS/MdeP

Attach.

cc: Messrs. B. R. Davis (2)  
H. A. Tregaskes  
D. W. Farren  
G. K. Hunter (2)  
D. P. Collins  
A. S. Melnyshyn  
T. J. Kovich  
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Foundations Files  
Gen. Files

*A. G. Sternac*

A. G. Sternac  
PRINCIPAL FOUNDATION ENGINEER

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FOUNDATION INVESTIGATION REPORT  
For  
Proposed Extension to the  
Existing Structure at the Crossing  
Of Highways 35 & 115 and Highway 2  
County of Durham, Township of Clarke  
District No. 7 (Port Hope)  
E.J. 68-F-21 -- M.P. 199-65-0

1. INTRODUCTION:

The Foundation Section was requested to carry out an investigation for the proposed extension to the existing structure at the Hwy. 35 & 115 and Hwy. 2 intersection, one mile east of Newcastle, Ontario. The request was contained in a memo from the Bridge Division (Mr. A. S. Mellingshyn, Regional Bridge Location Engineer), dated March 13, 1968. An investigation was subsequently carried out by this Section to determine the subsoil conditions at this site.

Presented in this report are the results of this investigation, together with the recommendations pertaining to the foundations of the proposed structure, and the stability of the approaches.

2. SUBSOIL CONDITIONS:

A total of five boreholes and dynamic cone penetration tests was carried out using a skid-mounted diamond drill adapted for soil sampling. The boundaries between the different deposits, together with detailed descriptions of the material in the deposits, are shown on the borelog sheets attached to this report.

The estimated stratigraphical profile, shown on Drawing 68-F-21A, is based upon this information.

From ground level downward, the different soil types encountered are as follows:

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

2.1) Clayey Silt with Sand and traces of Gravel (Fill Material):

A surficial deposit of clayey silt with sand and traces of gravel (fill material) was encountered in B.H.'s #1 and 2. This layer is about 10.5 ft. thick and has the following physical properties as determined from laboratory and field tests:

Liquid Limit	( $w_L$ )	:	26 - 31
Plastic Limit	( $w_p$ )	:	18 - 21
Moisture Content	( $w$ )	:	25 - 26
"N" values		:	7 - 13 blows/ft.

The consistency of the layer is estimated to range from firm to stiff.

In B.H.'s #3, 4 and 5, put down in the vicinity of the existing roadway, between 2.5 and 4.5 feet of granular fill was encountered immediately below ground surface.

2.2) Glacial Till (Heterogeneous Mixture of Clay, Silt, Sand and Gravel):

The heterogeneous deposit was encountered immediately below the surficial layers described above, at all borehole locations. The maximum thickness of this deposit was not established; the deposit was proven to extend down to elevation 286 at B.H. #4. The texture of the subsoil shows the deposit to be of glacial origin, in the form of a heterogeneous mixture of cohesive clayey silt, sand and gravel in the upper 9 ft. (B.H.'s #1 and 2), gradually changing to a basically non-cohesive mixture of silt, sand and gravel with traces of clay. The granular component of the deposit, generally, increases with depth. The exact boundary between the cohesive and non-cohesive material is shown on the appended borehole log sheets.

cont'd. /3 ...

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

2.2) Glacial Till (Heterogeneous Mixture of Clay, Silt, Sand and Gravel): (cont'd.) ...

The engineering properties of the deposit, as determined from field and laboratory tests, are as follows:

		<u>Upper Cohesive Zone</u>	<u>Lower Non-Cohesive Zone</u>
Liquid Limit	( $w_L\%$ )	: 24 - 35	13 - 15
Plastic Limit	( $w_p\%$ )	: 14 - 18	10 - 12
Moisture Content	( $w\%$ )	: 13 - 27	6 - 11
'N' values		: 32 - 100/9"	37 - 100/4"

Based on the 'N' values, the consistency of the upper cohesive portion of the deposit is estimated to be hard, and the relative density of the non-cohesive lower portion to be dense to very dense.

3. GROUNDWATER CONDITIONS:

The observations carried out during the period of the field investigation showed the groundwater levels in the borings to be at the following elevations:

B.H. #1	:	Elev. 315.0 ft.
B.H. #2	:	Elev. 321.5 ft.
B.H. #3	:	Elev. 311.0 ft.
B.H. #4	:	Elev. 310.0 ft.
B.H. #5	:	Elev. 310.0 ft.

cont'd. /4 ...

#### 4. DISCUSSION AND RECOMMENDATIONS:

The existing underpass structure at the site is a single-span structure with closed-end abutments, some 75 feet in length and 60 feet in width. To facilitate 4 lanes of traffic, it is proposed to extend the structure to the west by adding a second span about 75 feet in length. In addition, the width of the structure will be increased to about 80 feet.

Subsoil at the site consists of a surficial deposit of clayey silt with sand and traces of gravel (fill material), followed by a hard or very dense glacial till deposit extending at least 28 ft. below elevation 314, which is the existing grade of Hwy. #35 and 115.

According to available design drawings, the existing structure is founded on spread footings placed in the glacial till deposit at about elev. 307 ft. It is recommended that the extensions to 1) the existing west abutment, which will be the new pier, and 11) the existing east abutment be founded on spread footings at the above elevation. The proposed west abutment should be founded within the glacial till, at an elevation consistent with the frost protection requirements in the area - i.e., at or below elevation 310. An allowable safe bearing pressure of up to 5 t.s.f. can be used in design of spread footings. Due to the dense state of the granular glacial till the settlement will be negligible, provided the subsoil is not loosened as will be discussed later in this report. Any differential settlement between the existing footings and their extensions could be accommodated by providing a construction joint.

#### Dewatering:

At the location of the proposed pier and east abutment the groundwater level, at the time of the investigation, was at about elevation 310 to 311. Based on this, the excavations may extend down some 3 to 5 feet below the groundwater level, the actual extent depending on the seasonal fluctuations related to

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

Dewatering: (cont'd.) ...

the time of construction. Since the granular glacial till is relatively pervious some groundwater seepage can be expected in the excavations; further boiling may occur at the base of the excavation due to the unbalanced hydrostatic water pressure head. A dewatering scheme may, therefore, be required. One possibility is to carry out the excavation from within closed sheeting, which should be driven from about elevation 312. The sheeting should extend a distance below the proposed footing level equal to the unbalanced hydrostatic groundwater head. As an alternative, the groundwater level could be lowered below footing level by installing a wellpoint system.

At the west abutment location the groundwater level was encountered between elevations 315 (B.H. #1) and 321 (B.H. #2). It is considered that the higher groundwater level encountered at B.H. #2 may be a perched level occurring within the relatively impervious upper cohesive glacial till during periods of excessive precipitation. It is inferred, therefore, that the footing excavation at this site will be carried out some 5 feet below the groundwater level within the lower granular glacial till, again depending on seasonal fluctuations. An undisturbed and dry excavation base can be exposed by cutting an oversized excavation and installing a perimeter drainage ditch completely around the footing base. The ditches should be located approximately 5 feet away from the proposed footing edge and extend some 2-1/2 to 3 feet below footing level. The trenches so formed, should be gravity drained to a sump from where the water can be pumped away. It is recommended that the sequence of excavation be such that the excavations for the extensions be carried out prior to the excavation for the west abutment.

To prevent loosening of the subsoil at footing level, due to groundwater seepage or surface run-off, it is recommended that, as soon as foundation level is reached, a working mat of lean concrete be poured.

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

No stability problems are anticipated for the proposed cuts, provided standard 2:1 side slopes are employed and the groundwater control, aforementioned, is maintained during construction.

5. MISCELLANEOUS:

The field work, performed during the period of April 2 to April 9, 1968, was supervised by Mr. V. Korlu, Project Foundation Engineer, who also wrote this report.

The investigation was carried out under the general supervision of Mr. M. Devata, Supervising Foundation Engineer, who reviewed the report.

Equipment used was owned and operated by Dominion Soil Investigation Ltd. of Toronto.

April, 1968.



## APPENDIX I

TABLE 1. SUMMARY OF DATA FOR THE 1970-1971 SEASON



DEPARTMENT OF HIGHWAYS - ONTARIO

## RECORD OF BOREHOLE NO. 2

FOUNDATION SECTION

MATERIALS &amp; TESTING DIVISION

JOB 68-P-21

LOCATION Hwy. 35, 115 &amp; 2. Sta. 43 + 40 46.6' Lt.

ORIGINATED BY VK

W.P. 199-65-0

BORING DATE April 1, 1968

COMPILED BY VK

DATUM Geodetic

BOREHOLE TYPE Drill Tricone Bit, Drive Casing &amp; Wash

CHECKED BY

SOIL PROFILE		SAMPLES			DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT			REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	ELEV SCALE	20	40	60	80	100	PLASTIC LIMIT	
336.5	Ground Level						400	800	1200	1600	2000	WATER CONTENT % 10 20 30	Gr. Sa. Si. Cl.
0.0	Fill material.												
	Clayey silt with sand		1	SS	10								
	and trace of gravel.		2	SS	12	330							
	Stiff		3	SS	12								
326.5													
10.0	Het. mix. of clayey		4	SS	12								
	silt, sand & gravel.												
	Hard.		5	SS	12	320							
318.0													
18.5	(Glacial Fill)		6	SS	100								
	Het. mix of silt, sand												
	and gravel with traces		7	SS	100/6"	310							
	of clay.		8	SS	100/6"								6 42 42 10
	Very dense.		9	SS	100/6"	300							
295.0													
11.5	End of Borehole		10	SS	100/5"								
						290							

DEPARTMENT OF HIGHWAYS - ONTARIO

## RECORD OF BOREHOLE NO 3

FOUNDATION SECTION

MATERIALS &amp; TESTING DIVISION

JOB 67-P-21

LOCATION Hwy. 35, 115 &amp; 2. Sta. 43 + 28 102.3' Rt.

ORIGINATED BY VK

W.P. 192-05-0

BORING DATE April 5, 1968

COMPILED BY VK

DATUM Goodatic

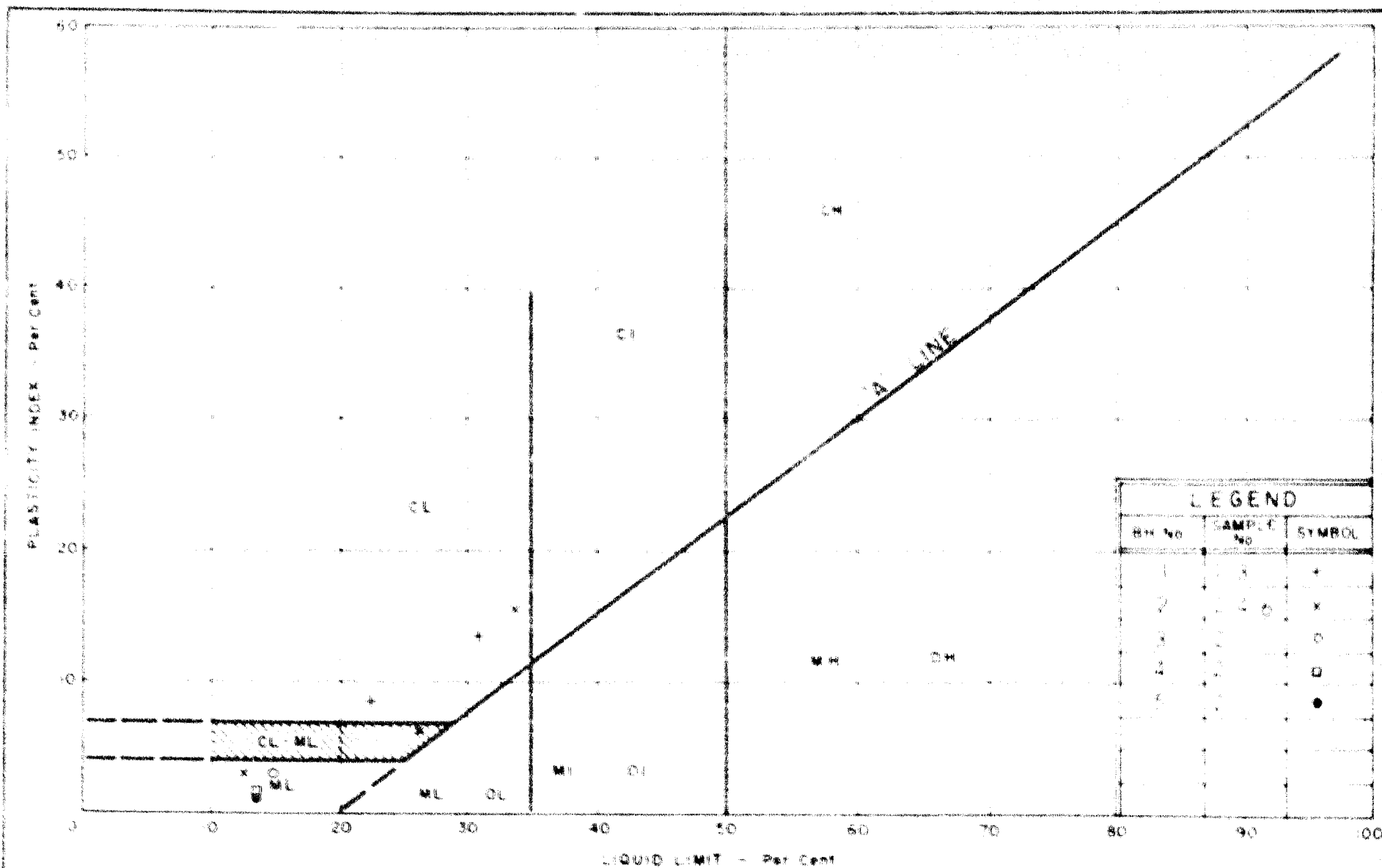
BOREHOLE TYPE Drill friction bit, Drive casing &amp; wash

CHECKED BY

SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT		REMARKS
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS / FOOT	ELEV SCALE	PLASTIC LIMIT	WATER CONTENT	
313.5	Ground Level			20 40 60 80 100				
311.0	Granular Fill			400 800 1200 1600 2000				
311.0	(Glacial Till)	1	SS	55	300			Gr. Sa. Si. Cl.
287.0	Het. mix. of silt, sand & gravel with traces of clay.	2	SS	100	290			
26.5	Very dense.	3	SS	100				
		4	SS	100				
		5	SS	100				
		6	SS	100				
		7	SS	100				
26.5	End of borehole							







DEPARTMENT OF HIGHWAYS  
MATERIALS and  
TESTING  
DIVISION

# PLASTICITY CHART

WP No 149-65-0

JOB No 68-F-21

# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT

SAND

GRAVEL

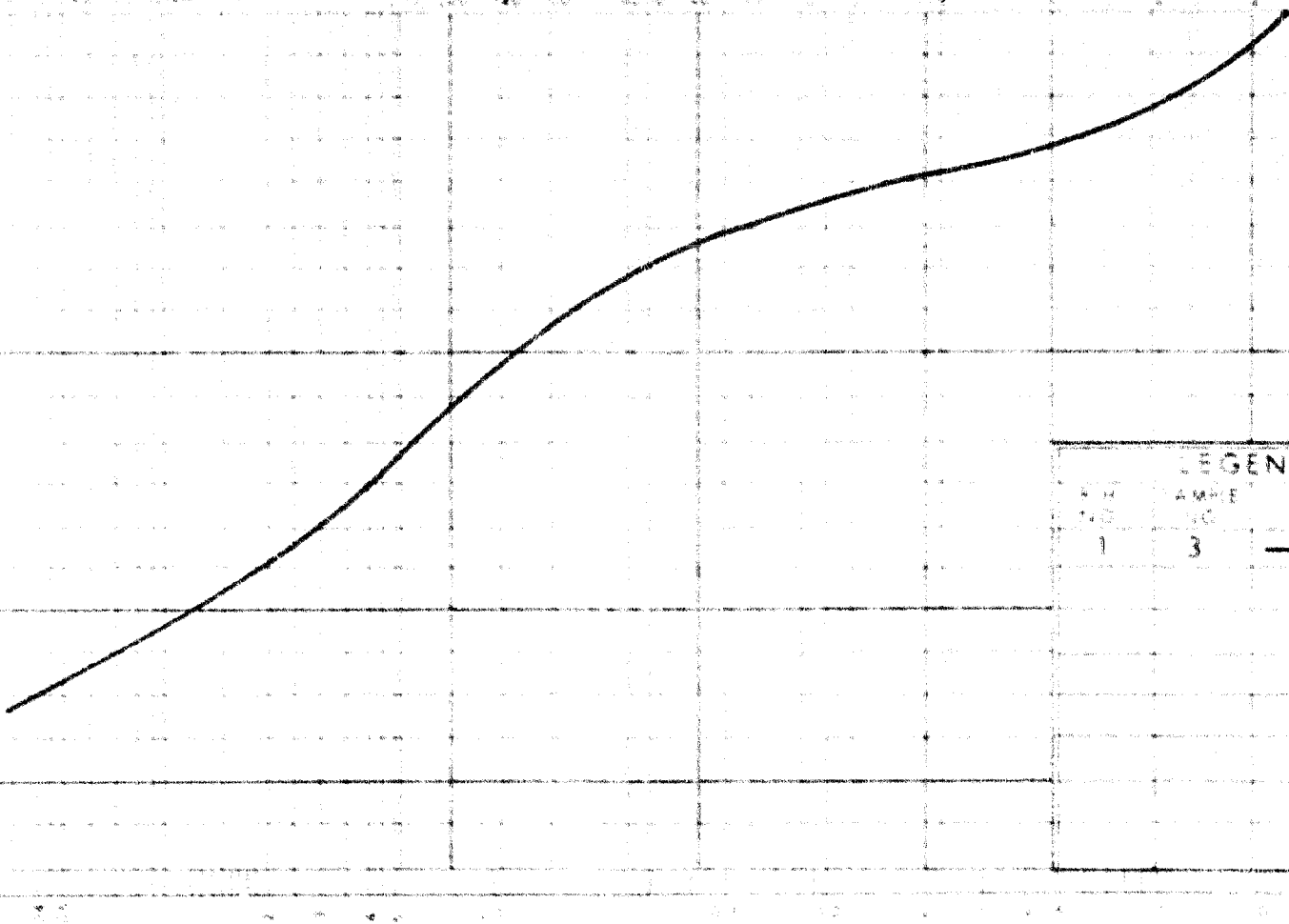
PERCENT PASSING THROUGH SIEVE OR ORIFICE

100 90 80 70 60 50 40 30 20 10 0

0.075 0.15 0.3 0.6 1.18 2.0 4.75 9.5 19 37.5 75 150 300 600 1200 2500 5000 10000

mm

NO. 20 40 60 100 200 400 80 160 325 660 1360 2800 5000 10000



LEGEND		
NO.	NAME	SYMBOL
1	CLAY	—
3	SILT	—

GRAIN SIZE IN MILLIMETERS



DEPARTMENT OF HIGHWAYS  
MATERIALS AND  
TESTING  
DIVISION

GRAIN SIZE DISTRIBUTION  
GLACIAL TILL  
HET. MIXTURE OF CLAYEY SILT, SAND & GRAVEL

WP No. 199-65-0

UCB No. 68-F-21



# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT

SAND

GRAVEL

PERCENT PASSING

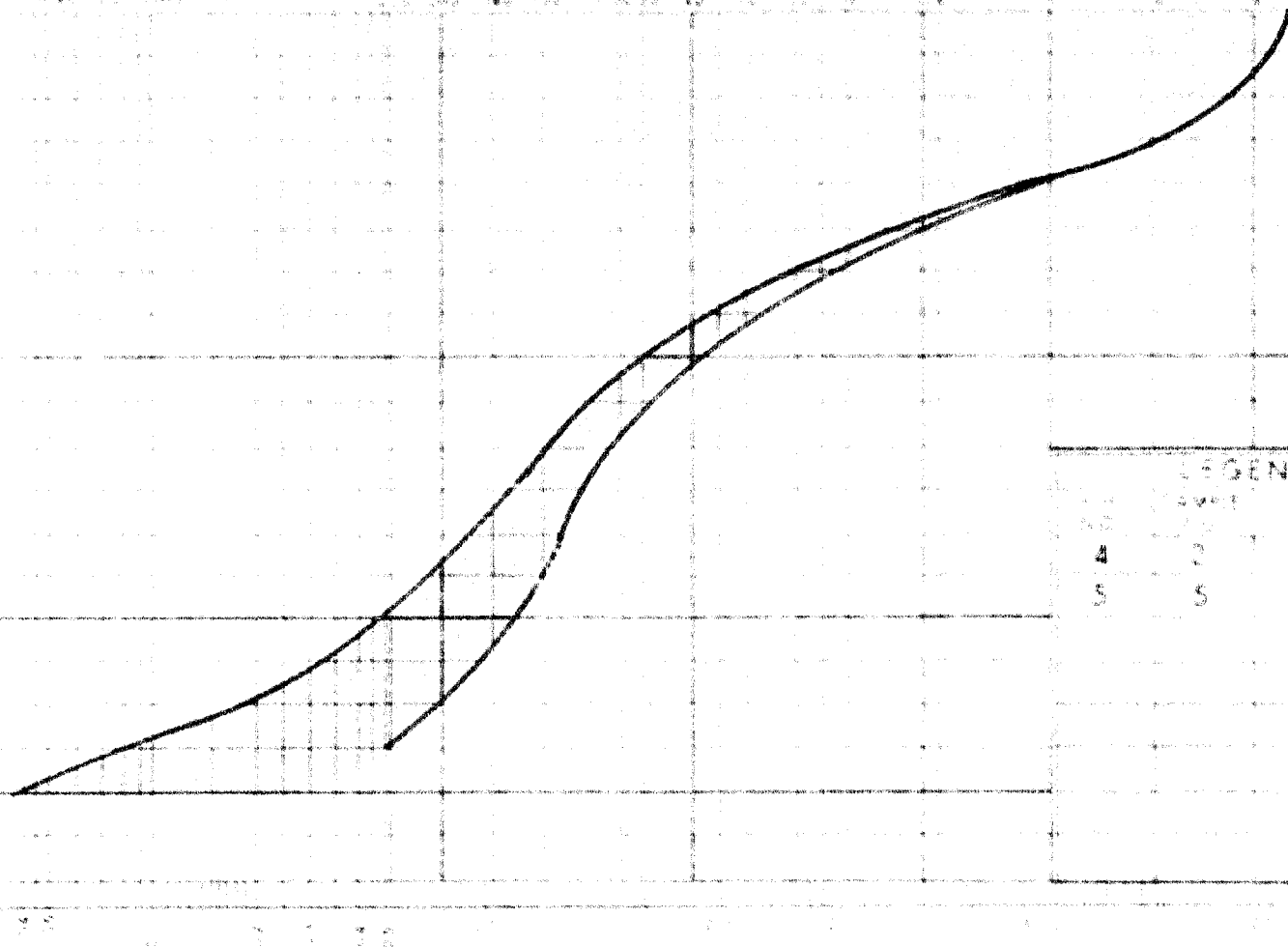
FINE

WASH

COARSE

NO

GRAVEL



## LEGEND

4

5

3

5

GRAIN SIZE IN MILLIMETERS



DEPARTMENT OF HIGHWAYS  
MATERIALS AND  
TESTING  
DIVISION

## GRAIN SIZE DISTRIBUTION GLACIAL TILL

HET MIXTURE OF SILT, SAND, GRAVEL WITH TRACES OF CLAY

WP No 199-65-0

JOB No 68-F-21

## 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 = $\frac{-\Delta e}{(1+e)\Delta\sigma}$
$c_v$	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
$\tau_f$	SHEAR STRENGTH
$c'$	EFFECTIVE COHESION INTERCEPT
$\phi'$	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
$c_u$	APPARENT COHESION
$\phi_u$	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
$\mu$	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 (YOUNG'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

#68-F-21

W.P. #199-65-0

HWY #2, #35 & #115

LINE 'F'

