

68-F-61-3

W.P. 144-67-01

HWY. # 560

LOT 8, CON. 5

NEW LISKEARD

MEMORANDUM

To: Mr. E. R. Saint,
Regional Materials Engineer,
Regional Office,
North Bay, Ontario.

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

ATTENTION:

DATE: January 17, 1969

OUR FILE REF:

IN REPLY TO

JAN 21 1969

SUBJECT:

FOUNDATION INVESTIGATION REPORT
For
Proposed Sec. Hwy. #560 Realignment
Lot 8 -- Concession 5
District No. 14 (New Liskeard)
W.J. 68-F-61-3 -- W.P. 144-67-01

Attached, we are forwarding to you, our detailed foundation investigation report on the subsoil conditions existing at the above mentioned 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/MdeF
Attach.

cc: Messrs. E. R. Saint (2)
H. A. Tregaskes
D. W. Farren
H. McArthur
D. A. O. White
B. A. Singh

Foundations Files
Gen. Files

A. G. Stermac
A. G. Stermac
PRINCIPAL FOUNDATION ENGINEER

TABLE OF CONTENTS

1. INTRODUCTION.
 2. DESCRIPTION OF THE SITE.
 3. FIELD INVESTIGATION PROCEDURE.
 4. LABORATORY TESTS.
 5. SOIL TYPES AND SOIL CONDITIONS:
 - 5.1) General.
 - 5.2) Varved Clay with Sand.
 - 5.3) Sand and Gravel.
 - 5.4) Dolomite - Bedrock.
 6. GROUNDWATER CONDITIONS.
 7. DISCUSSION AND RECOMMENDATIONS.
 8. MISCELLANEOUS.
-

FOUNDATION INVESTIGATION REPORT
For
Proposed Sec. Hwy. #560 Realignment
Lot 8 -- Concession 5
District No. 14 (New Liskeard)
W.J. 68-F-61-3 -- W.P. 144-67-01

1. INTRODUCTION:

A request for a foundation investigation at the proposed Sec. Hwy. #560 realignment from Hwy. #11 at Englehart, westerly to Charlton, was received from Mr. E. R. Saint, Regional Materials Engineer, in a memorandum, dated July 2, 1968.

A field investigation was carried out by the Foundation Section to determine the subsoil conditions existing at the site. Presented in this report are the results of this investigation, together with recommendations pertaining to the stability of the proposed cut sections and embankments.

2. DESCRIPTION OF THE SITE:

The site is located some 5 miles west of Englehart.

The surrounding area is flat, cultivated farmland dissected by deep, stream eroded valleys. The valley sides are steep and covered with bush.

3. FIELD INVESTIGATION PROCEDURE:

The field work consisted of eight sampled boreholes and 13 dynamic cone penetration tests.

Boring was achieved by means of conventional diamond drilling equipment adapted for soil sampling purposes. During the field investigation, disturbed and 'undisturbed' samples were obtained at various intervals. Disturbed samples were recovered by a split-spoon sampler, and the number of blows required to drive it were recorded. The energy used in driving conformed to the requirements of the Standard Penetration Test.

3. FIELD INVESTIGATION PROCEDURE: (cont'd.) ...

'Undisturbed' samples were obtained by means of 2-inch I.D. Shelby tubes which were pushed into the soil by hand. In-situ vane tests were carried out wherever possible, at elevations 12 inches below the various sample depths.

The locations and elevations are shown on Dwg. 68-F-61-3A which forms part of this report.

4. LABORATORY TESTS:

The samples were visually examined and classified at the site as well as in the laboratory. Tests were carried out in the laboratory for classification and shear strength determination purposes. These tests consisted of natural moisture content, Atterberg limits, bulk density, grain-size distribution, unconfined compression, undrained triaxial, laboratory vane and effective parameter determinations. The test results are shown on the Record of Borehole sheets in the Appendix of this report.

5. SOIL TYPES AND SOIL CONDITIONS:

5.1) General:

Subsoil at the site consists of an extensive deposit of varved clay with sand, underlain by a shallow zone of sand and gravel, underlain by bedrock.

Detailed descriptions of the various soil types observed are shown on the Borelog sheets in the Appendix.

The estimated stratigraphical profile is shown on Dwg. 68-F-61-3A. The various soil types are described in detail as follows:

5.2) Varved Clay with Sand:

This deposit was encountered in all boreholes and extended from ground level either to the depth of exploration, or to the sand and gravel zone. Reference should be made to the Record of Borehole sheets for the thickness of this zone.

5. SOIL TYPES AND SOIL CONDITIONS: (cont'd.) ...

5.2) Varved Clay with Sand: (cont'd.) ...

The material in the deposit consists of layers of clay and clayey silt to silt with sand. The thickness of the different layers was found to vary but, in general, they were in the order of 1/8" to 1/4" and 1/8" to 3/4", respectively. The clay layers appeared to be fissured.

Physical properties of the material, as determined from laboratory tests, are as follows:

	<u>Clay</u>	<u>Silt</u>
Natural Moisture Content (%) ...	50 to 75	22 to 39
Liquid Limit (%)	42 to 73	29 to 34
Plastic Limit (%)	23 to 33	20 to 24

The bulk density of the overall stratum varied from 109 to 124 PCF.

Typical grain-size distribution curves are included in the Appendix of this report on Fig. 1.

The 'N' values ranged from 5 to 27 blows per foot.

The shear strength of the deposit, in general, was found to vary with depth, being in the order of 2500 PSF at El. 875' and 600 PSF at El. 855'. A plot of all Shear Strength values versus Elevation is contained in the Appendix (Fig. 2).

Boreholes located in the valleys indicated that the varved clay deposit is softened by the surface run-off water.

The consistency of the overall stratum ranges from firm to very stiff.

5.3) Sand and Gravel:

An approx. 2 ft. thick layer of sand and gravel was found directly above the bedrock. The relative density may be described as compact to very dense.

5. SOIL TYPES AND SOIL CONDITIONS: (cont'd.) ...

5.4) Dolomite - Bedrock:

A dolomite type bedrock was proved in Borehole #2.

6. GROUNDWATER CONDITIONS:

The following water levels were observed during the field investigation:

<u>B.H. No.</u>	<u>Elev. (ft.)</u>
1	872.5
2	842.8
3	-
4	-
5	879.2
6	839.5
7	-
8	873.3
9	873.5
10	-
11	871.8
12	-
13	-

No artesian conditions were encountered.

7. DISCUSSION AND RECOMMENDATIONS:

It is proposed to realign Hwy. #560 between Sta. 173+00 and 184+00. The proposal will involve fills up to 26 ft. and cuts up to 15 ft.

The field investigation has revealed that the subsoil consists of varved clay, followed by a thin layer of sand and gravel, followed by dolomite bedrock.

Stability analyses, carried out in terms of total stresses, indicated that fills up to 28 ft., constructed with standard 2:1 slopes, will be stable.

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

At the bottom of the valley, areas of surficial soft material have been found. This material should be removed for its full horizontal and vertical extent under the proposed embankment, prior to placing the fill material.

It is estimated that the settlement under the deepest portion of the fills will be in the order of 3 inches.

No major problems are anticipated for the 15-ft. deep cuts, provided with standard 2:1 slopes.

8. SUMMARY:

A foundation investigation at the site of the proposed Hwy. #560 realignment is reported.

The subsoil consists of an extensive deposit of varved clay, followed by sand and gravel, followed by dolomite bedrock.

No major problems are anticipated for fills up to 28 ft. in height and cuts 15 ft. deep, provided 2:1 slopes are constructed.

Settlements up to 3 inches are expected.

All soft surficial material should be removed within the entire construction area.

Details are given in the foregoing section, "Discussion and Recommendations".

9. MISCELLANEOUS:

The field work was carried out during the period of July 22 to August 13, 1968. The equipment used was owned and operated by Canadian Longyear Co. Ltd.

The supervision of the field work, together with the preparation of this report, was carried out by Mr. P. Payer, Project Foundation Engineer, under the general supervision of Mr. K. G. Selby, Supervising Foundation Engineer.

January 1969

APPENDIX I

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 1

FOUNDATION SECTION

JOB 68-F-61-3 LOCATION Sta. 174 + 50 16' Lt.

ORIGINATED BY PP

W P 144-67-01 BORING DATE August 7 & 8, 1968

COMPILED BY _____ PR _____

DATUM Geodetic BOREHOLE TYPE Washbore NX Casing

CHECKED BY

[illegible]

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 3

FOUNDATION SECTION

JOB 68-F-61-3

LOCATION Sta. 180 + 66 42' Rt.

ORIGINATED BY WB

W P 1111-67-01


BORING DATE August 8, 1968

COMPILED BY PP

DATUM Geodetic

BOREHOLE TYPE Cone Test Only

CHECKED BY *JA*

SOIL PROFILE			SAMPLES			ELEV SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W			BULK DENSITY PCF	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	BLOWS / FOOT		25	50	75	100	125	Wp — W — WL WATER CONTENT %				
884.9	Ground Level															
0.0	Probably Varved Clay															
						880										
						870										
						860										
855.9																
29.0	End of Borehole															
						850										

End of cone test

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 5

FOUNDATION SECTION

JOB 68-F-61-3

LOCATION Sta. 181 + 88 @

ORIGINATED BY WR

W P 114-67-01

BORING DATE August 9, 1968

COMPILED BY PP

DATUM Geodetic

BOREHOLE TYPE Washbore - NX Casing

CHECKED BY *SL*

SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT ——— % PLASTIC LIMIT ——— % WATER CONTENT ——— %			BULK DENSITY PCF	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT	ELEV SCALE	25	50	75	100	125	W P	W L		
884.2	Ground Level														
0.0															
	Varved clay with traces of sand		1	SS	11	880									879.2
			2	TW	PM									121	
			3	TW	PM										
	Brown & Grey		4	TW	PM	870								120	0 3 86 11
			5	TW	PM									118	0 1 83 16
	Stiff to very stiff		6	TW	PM										
863.2															
21.0	End of Borehole					860									
						850									

End of cone test

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 7

FOUNDATION SECTION

JOH 68-F-61-3

LOCATION Sta. 176 + 17 31' Lt.

ORIGINATED BY PP

144-67-01

BORING DATE August 9, 1968

COMPILED BY _____ PP

DATUM Geodetic

BOREHOLE TYPE Cone Test only

CHECKED BY [Signature]

[illegible]

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 8

FOUNDATION SECTION

JOB 68-F-61-3

LOCATION Sta. 176 + 85 44' Rt. of Ø

ORIGINATED BY PP

W P 144-67-01

BORING DATE August 9, 1968

COMPILED BY WB

DATUM Geodetic

BOREHOLE TYPE Washbore - NX Casing

CHECKED BY *[Signature]*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W			BULK DENSITY PCF	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		25	50	75	100	125	WP	WL	W			
883.6	Ground Level																
0.0	Varved clay with some sand		1	TW	27	880											
			2	TW	PM												
			3	TW	PM												
			4	TW	PM	870											
	Firm to stiff		5	TW	PM												
			6	TW	PM	860											
			7	TW	PM												
053.3																	
30.1	End of Borehole					850											

SHEAR STRENGTH P.S.F.
 • Triaxial + Field
 o Unconfined

WATER CONTENT %
 20 40 60

+15.0
 +15.0
 +14.0 bounces

117 0 7 68 25
 111
 118 0 1 (99)
 873.3
 114
 114.5 0 0 90 10

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 9

FOUNDATION SECTION

JOB 68-F-61-3

LOCATION Sta. 179 + 90

ORIGINATED BY WB

W.P. 144-67-01

BORING DATE August 10, 1968

COMPILED BY PP

DATUM Geodetic

BOREHOLE TYPE Washbore - N X Casing

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT					LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W			BULK DENSITY PCF	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	BLOWS / FOOT		25	50	75	100	125	WP	W	WL		
							SHEAR STRENGTH P.S.F.					WATER CONTENT %				
							• Triaxial + Field Vane					○ Unconfined x Lab Vane				
							1000 2000					20 40 60				
882.1	Ground Level															
0.0	Varved Clay with sand Firm to very stiff		1	SS	9	880										0 2 91 7
			2	TW	PM					x	x					883.5
			3	TW	PM	870										
			4	TW	PM				σ		•	x			117.5	0 22 37 41
			5	TW	PM				+8.5						119	0 1 80 19
			6	TW	PM				+8.0							
			7	TW	PM	860			+12.0						114	
			8	TW	PM				+8.0						112	0 21 34 45
			9	TW	PM				+9.6						110	0 0 78 22
849.6						850			+5.6						111	0 3 50 47
32.5	End of Borehole										refusal					

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 11

FOUNDATION SECTION

JOB 68-F-61-3

LOCATION Sta. 177 + 63 21' Lt.

ORIGINATED BY PP

W.P. 114-67-03

BORING DATE August 10, 1968

COMPILED BY DP

DATUM Geodetic

BOREHOLE TYPE Washbore - NX Casing

CHECKED BY

SOIL PROFILE		SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W		BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		BLOWS / FOOT	SHEAR STRENGTH P.S.F. o Unconfined + Field Vane	WATER CONTENT % 20 40 60			
881.1	Ground Level										
0.0	Varved clay with some sand.		1	TW	PM					121	0 6 8 10
			2	TW	PM						
			3	TW	PM						
	Firm to stiff.		4	TW	PM						
			5	TW	PM					119	0 2 5 4 4
			6	TW	PM						
			7	TW	PM						
			8	TW	PM						
845.7											
35.4	End of Borehole										

End of cone test

DEPARTMENT OF HIGHWAYS - ONTARIO

RECORD OF BOREHOLE NO. 12

FOUNDATION SECTION

JOB 68-F-61-3

LOCATION Sta. 178 + 96 on Ø

ORIGINATED BY WB

W. P. 144-67-01

BORING DATE August 12, 1968

COMPILED BY _____ WB

DAYUM Geodetic

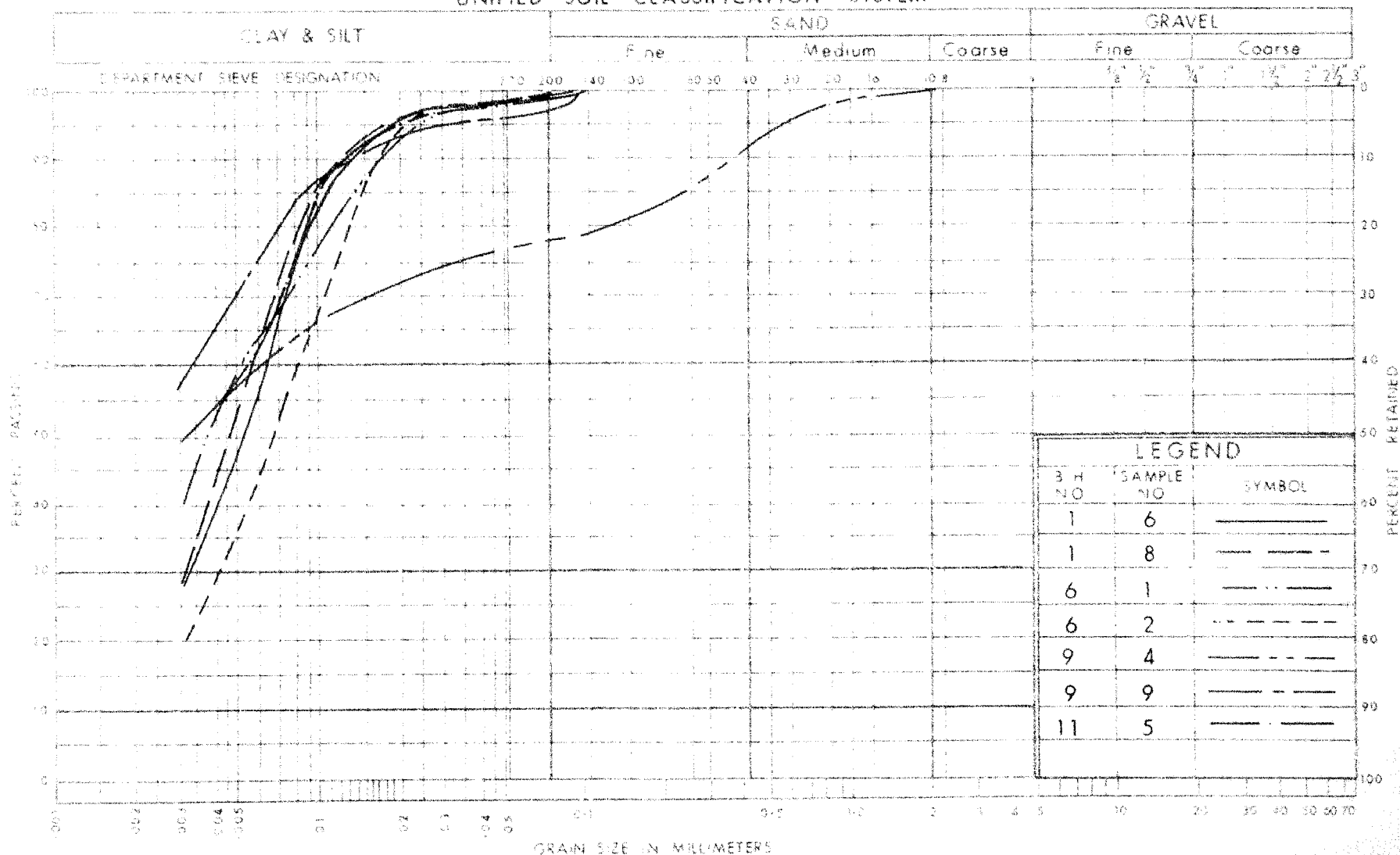
BOREHOLE TYPE Washbore - NX Casing

CHECKED BY AK

SOIL PROFILE			SAMPLES			DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT			LIQUID LIMIT ——— WL PLASTIC LIMIT ——— WP WATER CONTENT ——— W			BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT	ELEV SCALE	SHEAR STRENGTH P.S.F. Quick Triaxial + Field Vane o Unconfined				WATER CONTENT % 20 40 60		
857.9	Ground Level												
0.0	Varved Clay		1	SS	6								
	Firm		2	TW	PM		850						
847.1			3	TW	PM								
845.9	Sand and gravel		4	SS	50			+9.5					
12.0	End of Borehole						refusal						

DEFECTS IN NEGATIVE DUE TO
CONDITION OF ORIGINAL DOCUMENT

UNIFIED SOIL CLASSIFICATION SYSTEM



DEPARTMENT OF HIGHWAYS
MATERIALS and
TESTING
DIVISION

GRAIN SIZE DISTRIBUTION
VARVED CLAY

W.P. No. 144 - 67 - 01

JOB No. 68 - F - 61 - 3

FIG. 1

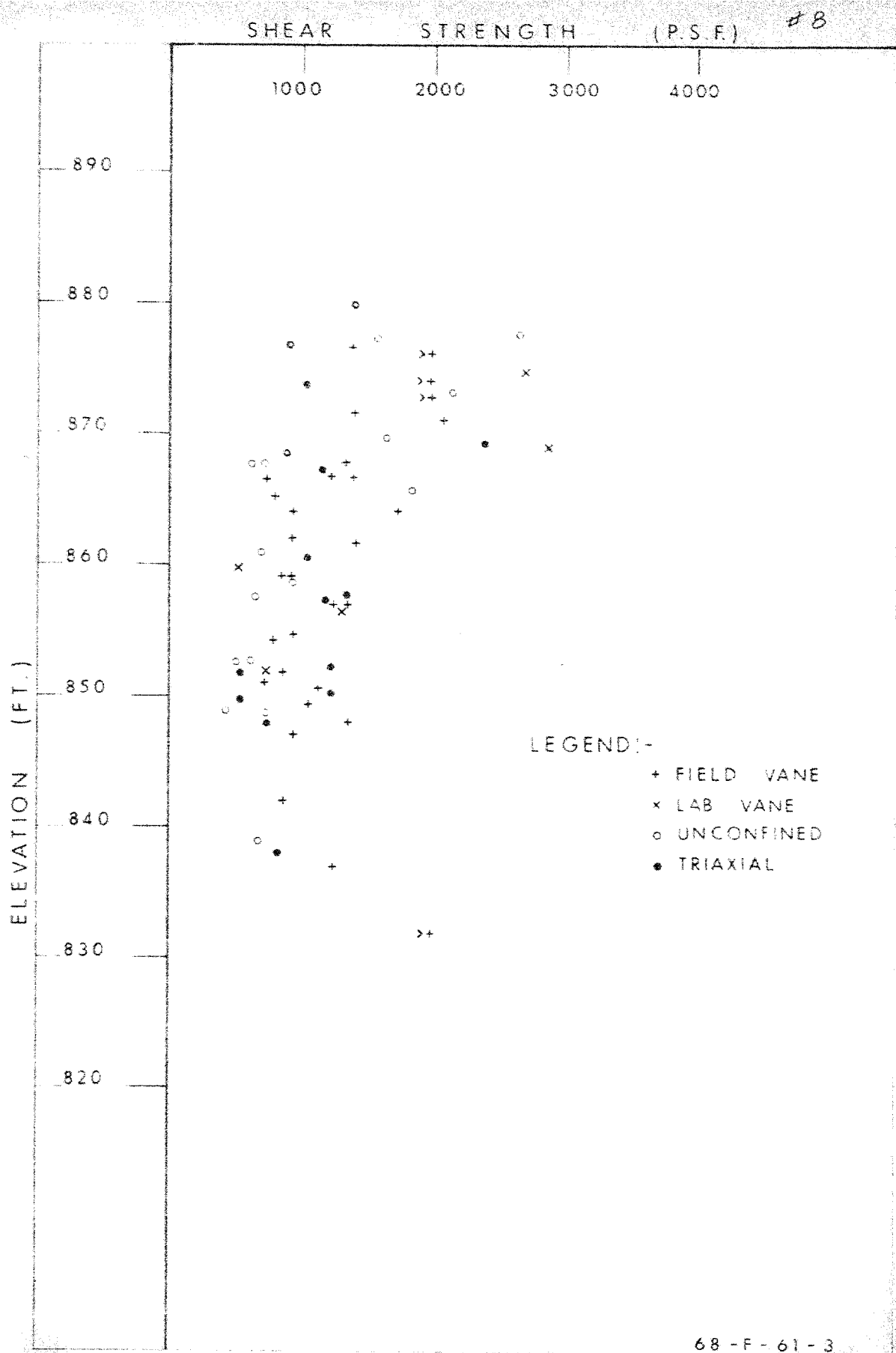


FIG. 2

68-F-61-3

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
WS	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 _u	UNCONFINED COMPRESSION	L.V	LABORATORY VANE
Q	UNDRAINED TRIAXIAL	F.V	FIELD VANE
Q _{cu}	CONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
Q _d	DRAINED TRIAXIAL	S	SENSITIVITY

ABBREVIATIONS USED IN THIS REPORT

SOIL PROPERTIES

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	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
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_i	SENSITIVITY

GENERAL

π	≈ 3.1416
e	BASE OF NATURAL LOGARITHMS 2.7183
$\log_e \sigma$ OR $\ln \sigma$	NATURAL LOGARITHM OF σ
$\log_{10} \sigma$ OR $\log \sigma$	LOGARITHM OF σ TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
L	LENGTH
M	MENT
F	FACTOR OF SAFETY

STRESS AND STRAIN

	POR: PRESSURE
	NORMAL STRESS
	NORMAL EFFECTIVE STRESS (σ' IS ALSO USED)
σ	
γ	
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

EARTH PRESSURE

d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	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
β	ANGLE OF SLOPE TO HORIZONTAL

