

G.I.F-30 SEPT. 1976

GEOCRES No. 40J16-39DIST. 1 REGION W.P. No. 346-65-01 & 02CONT. No. 75-027W. O. No. STR. SITE No. HWY. No. 402LOCATION C.N.R. OverheadSarniaNo. of PAGES -

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.REMARKS:

MEMORANDUM

( R.M. 113 LAB. Bldg )

~~40 J - 114~~

GEOCRES No.

TO: Mr. B. R. Davis,  
Bridge Engineer,  
Bridge Office,  
Admin. Bldg.

ATTENTION: Mr. S. McCombie

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

DATE: July 17, 1970

OUR FILE REF.

IN REPLY TO

JUL 24 1970

SUBJECT:

40J16-39

GEOCRES No.

FOUNDATION INVESTIGATION REPORT

For  
The Proposed C.N.R. Overhead of  
Highway #402, near Sarnia  
District No. 1 (Chatham)

W.O. 70-11045 -- W.P. 346-65-01 & 02

CONT. 75-27

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/MdeF  
Attach.

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

cc: Messrs. B. R. Davis  
H. A. Tregaskes  
D. W. Farren  
W. Zonnenberg  
F. C. Brown  
A. P. Watt (2)  
J. Roy  
B. A. Singh

Foundations Files ✓  
Gen. Files

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FOUNDATION INVESTIGATION REPORT  
For  
The Proposed C.N.R. Overhead of  
Highway #402, near Sarnia  
District No. 1 (Chatham)  
W.O. 70-11045 -- W.P. 346-65-01 & 02

1. INTRODUCTION:

A memo by Mr. A. P. Watt, Bridge Planning Engineer, Southwestern Region, was received by this Section on May 22, 1970, requesting a foundation investigation at the site of the proposed C.N.R. overhead structure of Hwy. #402.

The revised Hwy. #402 Line 'C' at this location, crosses the C.N.R. tracks some 100 ft. south of the originally proposed Line 'C', which has been shifted on account of unfavourable soil conditions, found farther east along the Modeland Rd. crossing. During a previous foundation investigation along the original line, a fairly thick deposit of organic material was revealed at the Modeland Rd. crossing. It was pointed out that, by shifting the line southward, the thickest portion of the organics could be avoided.

In the following sections the results of our investigations together with recommendations concerning foundations, are presented.

2. DESCRIPTION OF THE SITE:

The proposed crossing is situated some 400 ft. north of the existing level crossing of Hwy. #402 and the C.N.R. tracks. The vicinity is flat, occupied by farmland. Right west of the tracks the area is swampy, partially covered by shallow water.

Geologically the terrain belongs to the physiographic region known as the Huron Fringe. At this southerly portion of the region, behind sandy beaches of Lake Huron, some marshy lagoons may be found. These marshlands are usually underlain by marl or marly silt and clay.

### 3. FIELD AND LABORATORY INVESTIGATIONS:

A total of eight boreholes and one dynamic cone penetration was carried out during the recent field investigation at the locations of the future footings. Some four borings and five cone penetrations, implemented last November and December for the original line, were near enough to the revised footing locations, so that they could also be incorporated in this report.

A C.M.E. hollow stem auger was used for boring the overburden, while bedrock was proved by means of a conventional diamond core drill. Soil samples were taken along the entire depth of the overburden, using split-spoon and Shelby tube samplers. Split-spoons were advanced by performing standard penetration tests; Shelby tubes were pushed 18" into the undisturbed soils either mechanically or hydraulically. Field vane tests were taken regularly at 18" below soil samples in order to measure the undrained and remoulded shear strength of the materials. The boreholes were staked out and surveyed by personnel of the South-western Region.

Upon arrival in the laboratory, soil samples were visually examined and classified. Routine laboratory tests of moisture contents, Atterberg limits, grain-size analyses, unconfined and triaxial shear stress and a few consolidations were performed, to determine physical, shear strength and consolidation properties of the deposits.

Field and laboratory test results are compiled on the borelogs appended to the report. The locations and elevations of the boreholes, together with the stratigraphical cross sections at the footing locations, are shown on Drawing #70-11045A in the Appendix.

#### 4. SOIL CONDITIONS:

##### 4.1) General:

The soil stratigraphy noted in the boreholes, was similar to that encountered at the proposed Modeland Rd. and Wawanosh Drain crossings. The relatively thin organic topsoil was followed by sandy silts and silty sands, which in turn were underlain by clayey silts and silty clays. Under the approx. 110-ft. deep overburden, shale bedrock was observed. A brief description of the subsoils follows:

##### 4.2) Surficial Deposit:

The top foot or so, of the surficial deposit is black and dark brown organic material, which is underlain by sandy silts and silty sands. The entire depth of this recent alluvial deposit is between 4 ft. and 9.5 ft. Standard penetration tests carried out within this layer, yielded 'N' values of 2 to 7 blows per ft., indicating very soft to soft consistencies and very loose to loose relative densities. The sandy silts and silty sands are usually non-cohesive; in a few locations, however, a slight plasticity was noted, with plastic limits of approx. 17% and liquid limits of 24%. Due to the organic contamination, fairly high natural moisture contents were measured. One laboratory unconfined compression test resulted in a value of undrained shear strength of 250 PSF.

##### 4.3) Clayey Silt with Traces of Sand and Gravel:

The clayey silts were found at each borehole, extending to el. 529 - 530 ft., some 60 - 62 ft. below ground level. In (one location B.H. #8) the clayey silt was found to extend down to bedrock, intercepted by a 10-ft. thick layer of silty clay. The upper 5 - 10 ft. of the clayey silt is desiccated, having undrained shear strengths of 2000 PSF and over, as compared to an average shear strength of 1000 - 1200 PSF below the desiccated crust. Standard penetration 'N' values around 40 blows per ft. were obtained within the upper portion of the layer, decreasing

4. SOIL CONDITIONS: (cont'd.) ...

4.3) Clayey Silt with Traces of Sand and Gravel: (cont'd.) ...

to 6 - 9 blows per ft. farther down. This stratum has slight plasticity, the plastic limit moisture contents averaging 16% and the liquid limits 30%. The estimated bulk density of the layer is 130 - 133 PCF.

4.4) Silty Clay with Traces of Sand and Gravel:

Underlying the clayey silts, silty clays with traces of sand and gravel were revealed by the borings. This material was found to extend down to approx. el. 481 - 482 ft. to bedrock. The overall thickness of the deposit varies between 47 ft. and 70 ft. The undrained shear strengths of the silty clays are slightly lower than the overlying silts, and may be assumed to average 1100 PSF. The consistency of the layer ranges from firm to stiff. The mean natural moisture content is estimated to be 24%, the plastic limit 19%, and the liquid limit 38%. Above values indicate a normally consolidated or slightly overconsolidated material with intermediate plasticity. The bulk density of the clays is around 122 - 124 PCF.

4.5) Bedrock:

Bedrock was drilled with diamond shoes, using AXT size core barrels in two boreholes. A third borehole was augered down to the top of the rock, which was assumed at the refusal of farther penetration. The rock surface was established at el. 481.5 ft. - 481.8 ft., some 110 ft. - 111 ft. below ground level. Bedrock was identified to be black shale of the Kettle Point formation. The drilling yielded 85 - 95% recovery, implying a fairly sound unweathered texture.

4.6) Groundwater Conditions:

Water levels were encountered in every borehole, being some 1.5 - 2.0 ft. below ground surface. It is believed that the water level is somewhat deeper during the very dry seasons, but it appears likely that the footing excavations will extend below the water table.

## 5. DISCUSSION AND RECOMMENDATIONS:

### 5.1) General:

It is proposed to construct a three-span twin structure to carry Hwy. #402 over the C.N.R. tracks. The profile grade of the highway at the crossing, will be around el. 624 ft., resulting in approach embankments of approx. 32 ft. height. The uppermost soil stratum was found to consist of a thin layer of organics followed by loose to very loose sandy silts of an overall thickness of 5.7 ft. Hard to firm clayey silts and silty clays form the main body of the overburden, extending down to some 110 ft. below ground level, where bedrock was observed.

### 5.2) Structure Foundation:

Soil conditions were found to be favourable to support the structure either on spread footings or friction piles within the overburden. Alternatively, end-bearing piles driven to bedrock may also be considered.

It is assumed that the abutments are planned to spill through, hence spread footings will probably not be practical in this case. Abutments, therefore, should be supported on short 12-3/4" O.D. steel tube friction piles with 1/4" wall thickness. Piles should be driven through the approach fills to approx. el. 583 - 584 ft., some 8 - 9 ft. below original ground level, at which depth a slightly desiccated crust exists. Safe design loads of 25 Ton per pile may be employed on above piles.

Piers may be supported either on friction piles within the overburden or on spread footings. In adopting friction piles, No. 14 timber piles are recommended, which should be treated to prevent decay, since part of the piles might be above the water level. Piles should have a minimum of 45 ft. embedded length in original soil, in which case, 20 Ton per pile design loads may be used.



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

5.2) Structure Foundation: (cont'd.) ...

In the case of using spread footings, they should be placed at el. 586.0 ft., some 6 - 6.5 ft. below existing ground level. At this elevation safe loads of 2.0 TSP are recommended on the footings.

As an alternative, all the footings may be supported on end-bearing piles. Steel H-piles are recommended in this case, piles being driven down to bedrock around el. 481 - 482 ft. The maximum allowable design loads on the particular H-section may be assumed on the piles, provided they are fully supported on sound bedrock.

Pile caps should have a minimum of four ft. cover for frost protection; the footing excavations of the piers will likely extend below the water level. It is believed that, at the bottom of the excavations, the clayey silts will have adequate internal strength, so that no instability will occur. The silty sands and sandy silts overlying the clayey silts, however, are very susceptible to conditions of unbalanced hydrostatic head. To prevent these soils from 'boiling', a dewatering scheme may be necessary.

5.3) Approach Fills:

Approach fills of approx. 32 ft. height will be necessary for the crossing. It is believed that such fills will remain stable, provided that they are constructed with 2 horizontal to 1 vertical slopes. The organic material should be removed under the embankments in accordance with D.H.O. standards. Based on past experience, 3 - 4" differential settlements are anticipated under the structure.

6. MISCELLANEOUS:

The recent field work was carried out during the period June 15 - 26, 1970, under the supervision of Messrs. A. K. Barsvary, Senior Foundation Engineer, and T. Preston, student technician.

Equipment used was owned and operated by P.V.K. Drilling Company, Burford, Ontario.

This report was written by Mr. A. K. Barsvary and reviewed by Mr. K. G. Selby, Supervising Foundation Engineer.

July, 1970

APPENDIX I

[illegible]

20  
15 — 5 % STRAIN AT FAILURE  
10

DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

## RECORD OF BOREHOLE No. 2

FOUNDATION SECTION

JOB 70-11045

LOCATION STA. 20 + 71, 69.5 Ft. Lt. of  $\phi$ 

ORIGINATED BY T.P.

W.P. 346-65-01 &amp; 02

BORING DATE June 24, 1970

COMPILED BY A.K.B.

DATUM Geodetic

BOREHOLE TYPE C.M.E. Auger

CHECKED BY *ll*

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION		RESISTANCE	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		SHEAR STRENGTH P.S.F.			WATER CONTENT %				
							○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB. VANE		$W_P$	$W$	$W_L$		
						1000	2000	10	20	30				
592.5	Ground Level													
0.0	Black organics & sandy silt--V. loose		1	SS	2	590								
685.5			2	SS	22									
7.0			3	TW	PH									
			4	SS	23	580								
			5	SS	9									
	Clayey silt with traces of sand & gravel		6	SS	13									
	hard to firm		7	TW	PH	570								
			8	TW	PH	560								
			9	TW	PH	550								
			10	TW	PH	540								
530.0						530								
62.5	Silty clay with traces of sand & gravel		11	TW	PH									
	firm to stiff		12	TW	PH	520								
						490								
481.5	Probable Bedrock													
110.0	End of borehole													

DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

## RECORD OF BOREHOLE No.3

FOUNDATION SECTION

JOB 70-11045

LOCATION STA 21 + 37, 69.5 Ft. Rt. of  $\emptyset$ 

ORIGINATED BY T.P.

W.P. 346-65-01 &amp; 02

BORING DATE June 11-15, 1970

COMPILED BY A.K.B.

DATUM Geodetic

BOREHOLE TYPE C.M.E. Auger &amp; Washboring, BX casing

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					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		BLOWS / FOOT					SHEAR STRENGTH P.S.F.					WATER CONTENT %	
							20	40	60	80	100	P.S.F.						
591.9	Ground Level																	
0.0	Black organics & sandy silt		1	TW	PM	590												
585.9	V. Loose		2	SS	32													
6.0	Clayey silt with traces of sand & gravel		3	TW	PH	580												
			4	SS	15													
			5	TW	PH	570												
			6	SS	10													
			7	TW	PH	560												
			8	SS	6	550												
			9	TW	PH	540												
529.0			Boulder	10	SS	100/1"	530											
62.9	Silty clay with traces of sand & gravel	11	SS	34	520													
		12	SS	13	510													
		13	TW	PM	500													
481.7	Shale Bedrock																	
110.2		14	RC	Rec. 95%	480													
477.7																		
114.2	End of borehole																	

20  
10-5 % STRAIN AT FAILURE  
10

CHECKED BY

FOUNDATION SECTION

[illegible]

FOUNDATION SECTION

ORIGINATED BY T D

COMPILED BY A.K.B.

CHECKED BY *AK*

[illegible]



DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

# RECORD OF BOREHOLE No. 6

FOUNDATION SECTION

JOB 70-11045 LOCATION STA 20 + 98 Offset 60 Lt.

ORIGINATED BY G.A.

W.P. 346-65-01 & 02 BORING DATE Dec. 4/69

COMPILED BY \_\_\_\_\_

DATUM Geodetic

BOREHOLE TYPE Washboring

CHECKED BY HK

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					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		BLOWS / FOOT					SHEAR STRENGTH P.S.F.					WATER CONTENT % 10 20 30
							20	40	60	80	100	○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB. VANE				
592.0	ground level																
0.0	organics & silty sand		1	SS	4	590											
587.0	loose		2	SS	21												
5.0	Clayey silt with traces of sand & gravel  very stiff to stiff		3	SS	31												
			4	TW	PH	580									132.0		
			5	SS	12												
			6	TW	PH	570									228.0		
			7	SS	11												
			8			560											
			9	SS	30										n.q.		
554.0																	
38.0	End of borehole					550											

SHEAR STRENGTH P.S.F.

○ UNCONFINED + FIELD VANE  
● QUICK TRIAXIAL x LAB. VANE

1000 2000

End of cone test

+S 1.9

+S 2.9

+S 2.4

+S 1.8

DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

## RECORD OF BOREHOLE No. 7

FOUNDATION SECTION

JOB 70-11045

LOCATION STA 20 + 61, 69.5 Ft. Rt. of C

ORIGINATED BY T.P.

W.P. 346-65-01 & 02

BORING DATE June 25, 1970

COMPILED BY A.K.B.

DATUM Geodetic

BOREHOLE TYPE C.M.E. Auger

CHECKED BY *[Signature]*

[illegible]

DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

## RECORD OF BOREHOLE No. 8

FOUNDATION SECTION

JOB 70-11045

LOCATION STA 20 + 34 32.5 Ft. Rt of C

ORIGINATED BY T.P.

W.P. 346-65-01 &amp; 02

BORING DATE June 22-23, 1970

COMPILED BY A.K.B.

DATUM Geodetic

BOREHOLE TYPE C.M.E. Auger

CHECKED BY

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		SHEAR STRENGTH P.S.F.		WATER CONTENT %						
							○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE x LAB. VANE	$w_p$	$w$	$w_L$				
592.7	Ground Level							1000	2000	10	20	30			
0.0	Black organics & very loose sand		1	SS	3	590							0 = 81		
4.5	Clayey silt with traces of sand and gravel  ; Hard to stiff		2	SS	27						○				
			3	SS	36						○				
			4	TW	PH	580			○	●	○	○		135	
			5	SS	16							○			
			6	TW	PH	570			○			○		130	
			7	SS	9				+				○		
			8	SS	17	560							○		
557.7			35.0 Silty clay, traces of sand & gravel--firm	9	TW	PM	550			○				○	116.5
517.7	45.0 Clayey silt with traces of sand & gravel  stiff	10		SS	6	540							○		
		11	TW	PM	530			○	●			○		124	
		12	TW	PH	520										
511.2		81.5 End of boreholes							○				○	121.5	



DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

# RECORD OF BOREHOLE No. 10

FOUNDATION SECTION

JOB 70-11045 LOCATION STA 21+57 offset 69' LT. ORIGINATED BY G.A.  
W.P. 346-65-01 & 02 BORING DATE Dec 1967 COMPILED BY G.A.  
DATUM Geodetic BOREHOLE TYPE Dynamic Cone Penetration CHECKED BY [Signature]

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE	LIQUID LIMIT — $w_L$	BULK DENSITY $\gamma$	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT	PLASTIC LIMIT — $w_p$		
592.1	Ground Level						SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE	WATER CONTENT % $w_p$ — $w$ — $w_L$	P.C.F.	GR, SA, SI, CL
0.0	Cone Penetration Only					590				
578.1						580				
14.0	End of cone test					570				

End of cone test

DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

# RECORD OF BOREHOLE No. 11

FOUNDATION SECTION

JOB 70-11045 LOCATION STA 21 + 64, 34 Ft. Rt. of E ORIGINATED BY A.K.B.  
W.P. 346-65-01-02 BORING DATE June 26, 1970 COMPILED BY A.K.B.  
DATUM Geodetic BOREHOLE TYPE C.M.E. Auger CHECKED BY [Signature]

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		SHEAR STRENGTH P.S.F.		$w_p$ — $w$ — $w_L$ WATER CONTENT % 10 20 30				
592.2	Ground Level												
0.0	Black organics & silty sand-V. loose		1	SS	2								
587.2			2	SS	32								
5.0	Clayey silt with traces of sand & gravel		3	SS	14								
	hard to stiff		4	SS	10								
571.2													
21.0	End of borehole												

DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

## RECORD OF BOREHOLE No. 12

FOUNDATION SECTION

JOB 70-11045

LOCATION STA 21 + 95, 50 Ft. Lt. of  $\varnothing$

ORIGINATED BY A.K.B.

W.P. 346-65-01-02

BORING DATE June 26, 1970

COMPILED BY A.K.B.

DATUM Geodetic

BOREHOLE TYPE C.M.E. Auger

CHECKED BY

[illegible]

DEPARTMENT OF HIGHWAYS- ONTARIO  
MATERIALS & TESTING OFFICE

## RECORD OF BOREHOLE No. 14

FOUNDATION SECTION

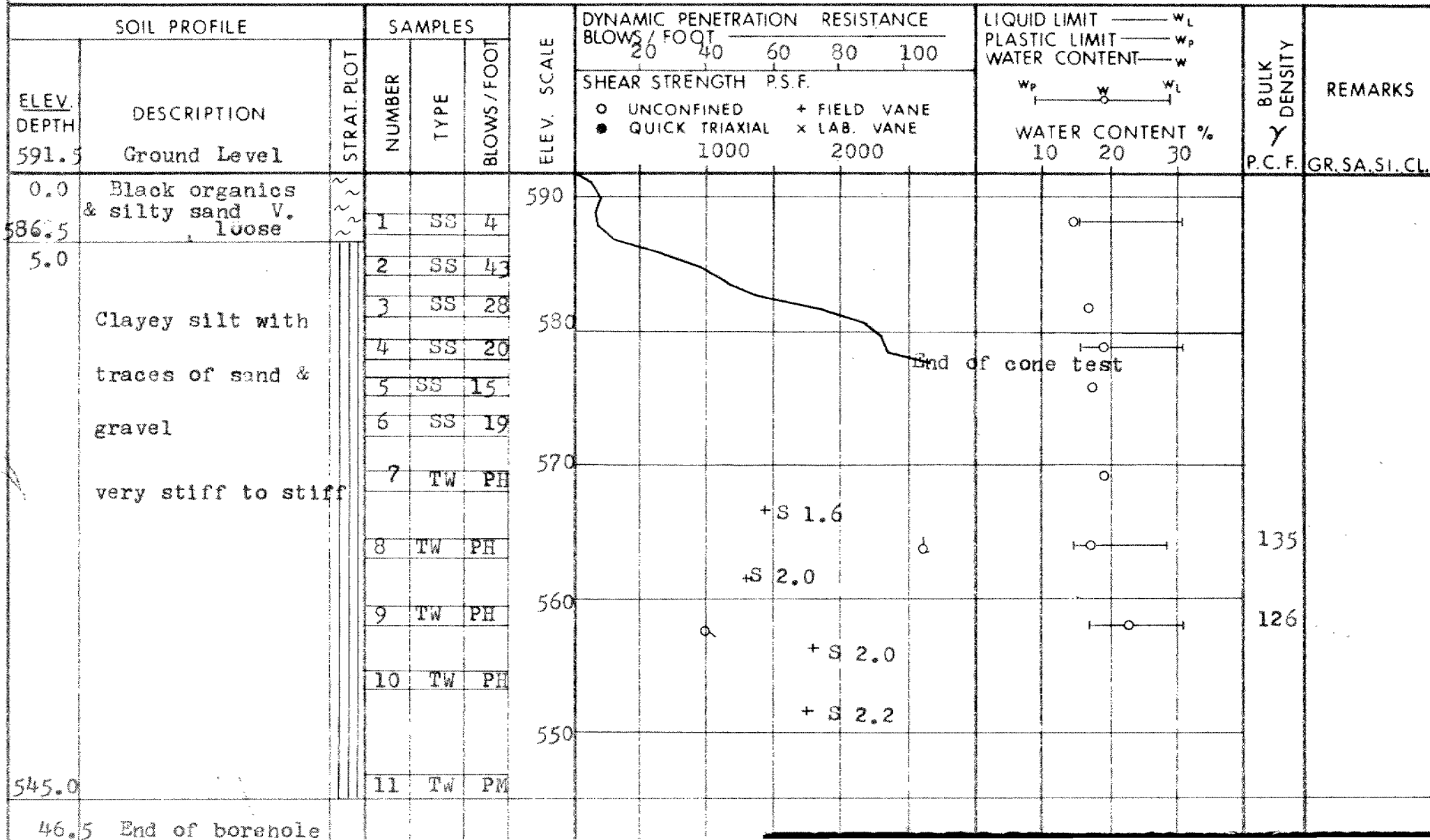
JOB 70-11045 LOCATION STA 21 + 96 Offset 86' LT.

ORIGINATED BY P.P.

W.P. 346-65-01&amp;02 BORING DATE Dec. 1 &amp; 2, 1969

COMPILED BY G.A.

DATUM Geodetic BOREHOLE TYPE Cont. Flt. Auger

CHECKED BY *W.C.*



## 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

Qu	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
Q	UNDRAINED TRIAXIAL	F.V.	FIELD VANE
Qcu	CONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
Qd	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
$\sigma'$	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

