

G.I.-30 SEPT. 1976

GEOCRES No. 40I14-97DIST. 2 REGION W.P. No. 41-66-06CONT. No. 77-61W. O. No. STR. SITE No. 19-546HWY. No. 402LOCATION County Rd. 43 UnderpassNo. of PAGES -=====OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT. REMARKS:

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS, ONTARIO

MEMORANDUM

TO: A.P. Watt (2)
Regional Structural Planning Eng.
Southwestern Region, London

FROM: Soil Mechanics Section
Geotechnical Office
West Building, Downsview

ATTENTION:

DATE: September 24, 1975

OUR FILE REF.

IN REPLY TO SEP 29 1975

SUBJECT:

40114-97

GEOCRES No.

FOUNDATION INVESTIGATION REPORT

For

* White Oaks Road Bridge, Hwy 402
Twp. of Westminster, Dist. 2, London
W.P. - 41-66-06, Site 19-546

**(County Rd. 43 U'Pass)*

Attached we are forwarding to you our detailed Foundation Investigation Report on the subsoil conditions existing at the above mentioned site.

We believe that the factual data and recommendations contained therein will prove adequate for your design requirements. Should additional information be required, please do not hesitate to contact our office.

K. G. Selby

K.G. SELBY
Supervising Engineer

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FOUNDATION INVESTIGATION REPORT
for
White Oaks Road Bridge, Hwy 402
Twp. of Westminster, Dist. 2, London
W.P. - 41-66-06, Site 19-546

1. INTRODUCTION

This report is to provide information for the design of the proposed underpass at the above location. The subsoil information is based on three sampled boreholes and three dynamic cone penetration tests. The underpass as proposed will consist of 16' approach embankments and a two span bridge with each span being 107 feet in length.

2. DESCRIPTION OF THE SITE

White Oaks Road crosses the proposed alignment of Hwy. 402 .5 miles west of the junction of Hwys. 401 and 402. The surrounding area is flat arable land engaged in mixed farming.

3. SUBSOIL

Subsoil at this site consists of about 10 feet of loose to compact silt to clayey silt overlying approximately 85 feet of very stiff to hard clayey silt. The average undrained shear strength of the upper portion of this clayey silt layer is assessed to be 2500 p.s.f. Underlying this layer some 95 feet below the ground surface is a layer of very dense sandy silt, some gravel and clay. Standard Penetration "N" values for this layer, in which the two deepest boreholes were terminated, were generally in excess of 100 blows per foot.

4. GROUNDWATER

Very little groundwater was encountered in the silt to clayey silt layer during the field investigation carried out during August. It would however, be reasonable to expect much more groundwater in this layer at other seasons of the year.

The clayey silt stratum is relatively impervious so that ground-water should not be a problem in this layer.

Water with a sub-artisian head was encountered in the sandy silt layer at a depth in excess of 90 feet.

5. RECOMMENDATIONS

5.1) Perched Abutments

The abutments may be constructed within the approach fills supported on well compacted granular "A". A net safe load of 2.5 t.s.f. may be assumed. For calculations of sliding resistance a friction coefficient of .55 may be assumed to apply between the footing and granular "A". A construction scheme is outlined in Figure 1 of the Appendix.

5.2) Center Pier

It is recommended that the center pier be supported on spread footings at approximate elevation 840. A net safe bearing pressure of $2\frac{1}{2}$ tons per sq. foot may be used for design purposes. Resistance to sliding may be determined using an adhesion value of 2000 lb./sq. ft.

5.3) Settlements

Total short and long term settlements of approximately 2 inches at the abutments and 1 inch at the center pier are anticipated.

5.4) Pile Footing Alternative

Any or all footings may be placed on piled foundations.

A design value of 30 tons per pile may be used for 40 foot #14 "treated" timber piles.

Steel H piles will reach their structural loading capacity if driven to approximate elevation 740 some 110 feet below the ground surface.

5.5) Dewatering

If the center pier footing is founded in the clayey silt stratum no problems with boiling or heaving of the bottom of the excavation are anticipated. It may however, be necessary to provide sumps for removal of seepage from the silt to clayey silt layer above.

5.6) Approach Embankments

No stability problems are anticipated with embankment fills (16 ft) if 2:1 slopes are employed. If timber piles are used to support the abutments care should be taken to select material which does not exceed 1 inch grain size to build that portion of the embankment through which they will be driven.

5.7) Frost Protection

All pile caps or spread footings should be protected against frost action by a minimum 4 feet of cover.



A handwritten signature in black ink, appearing to read "P.J. Stuart", written over the printed name.

P.J. STUART P. Eng.
Project Engineer

A handwritten signature in black ink, appearing to read "K.G. Selby", written over the printed name.

K.G. Selby P. Eng.
Supervising Engineer

September 1975

APPENDIX

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS-ONTARIO
ENGINEERING SERVICES BRANCH-GEOTECHNICAL OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE NO 1

WP 41-66-06 LOCATION Co-ords. 15,591,250 N; 1,336,890 E. ORIGINATED BY RD
DIST 2 HWY 402 BORING DATE August 7-8, 1975 COMPILED BY RD
DATUM Geodetic BOREHOLE TYPE Hollow Stem Augers CHECKED BY *CP*

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT W_L PLASTIC LIMIT W_P WATER CONTENT W			UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	W_P	W	W_L		
848.8	Ground Level															
0.0	Silt to clayey silt, trace of sand.															
	Loose to Compact		1	SS	9											
838.8			2	SS	19											
10.0			3	SS	19											
	Clayey silt, some sand, trace of gravel.		4	SS	20											
			5	SS	17											
			6	SS	18											
			7	SS	21											
			8	SS	31											
	Very Stiff to Hard															
			9	SS	14											
			10	SS	77											
			11	SS	46											
			12	SS	31											
755.8																
93.0	Sandy silt, some gravel and clay.															
	Very Dense															
744.8			13	SS	32/6"											
104.0																

20
15 ϕ 5 % STRAIN AT FAILURE
10

Continued

RECORD OF BOREHOLE NO 1 Continued

WP 41-66-06 LOCATION Co-ords. 15,591,250 N; 1,336,890 E. ORIGINATED BY RD
 DIST 2 HWY 402 BORING DATE August 7-8, 1975 COMPILED BY RD
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Augers CHECKED BY CP.

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w			UNIT WEIGHT γ	REMARKS % GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES		20	40	60	80	100	w_p	w	w_L		
744.8	continued															
104.0	Sandy silt, some gravel and clay. Very Dense		14	SS	100/4"	740						o				
730.5			15	SS	101/4"							o				27 31 31 11
118.3	End of Borehole W.L. not established															

RECORD OF BOREHOLE NO 2

WP 41-66-06 LOCATION Co-ords. 15,591,135 N; 1,336,926 E. ORIGINATED BY RD
 DIST 2 HWY 402 BORING DATE August 11, 1975 COMPILED BY RD
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY *EP*

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100		
849.1	Ground Level						SHEAR STRENGTH						
							O UNCONFINED + FIELD VANE • QUICK TRIAXIAL x LAB VANE						
							LIQUID LIMIT w_L PLASTIC LIMIT w_p WATER CONTENT w w_p — w — w_L WATER CONTENT % 10 20 30						
0.0	Silt to clayey silt, trace of sand.												
842.1	Compact		1	SS	19								0 7 81 12
7.0	Clayey silt, some sand, trace of gravel.		2	SS	22	840							10 15 50 25
			3	SS	21								
			4	SS	19								
			5	SS	20								
			6	SS	23	830							
			7	SS	21								
	Very Stiff to Hard		8	SS	24	820							
			9	SS	14								
			10	SS	37	810							
			11	SS	37	800							
			12	SS	32	790							
782.6													5 16 55 24
66.5	End of Borehole												
	Note: W.L. not established.												

RECORD OF BOREHOLE NO 3

WP 41-66-06

LOCATION Co-ords. 15,591,022 N; 1,336,962 E.

ORIGINATED BY RD

DIST 2 HWY 402

BORING DATE August 11-13, 1975

COMPILED BY RD

DATUM Geodetic

BOREHOLE TYPE Hollow Stem Augers

CHECKED BY CP

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT		LIQUID LIMIT ——— w_L PLASTIC LIMIT ——— w_p WATER CONTENT ——— w w_p ——— w ——— w_L WATER CONTENT % 10 20 30		UNIT WEIGHT γ	REMARKS % GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		SHEAR STRENGTH						
							20 40 60 80 100						
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						
850.3	Ground Level												
0.0	Silt to clayey silt, trace of sand.					850							
843.3	Compact		1	SS	16					○		0 1 79 20	
7.0	Clayey silt, some sand, trace of gravel. Stiff to Hard		2	SS	16					○		0 5 54 41	
			3	SS	15					○			
			4	SS	13					○			
			5	SS	14					○			
			6	SS	18								
			7	SS	18						○		
			8	SS	22		820				○		
				9	SS	17	810						
				10	SS	127	800				○		
				11	SS	67					○		
						790							
			12	SS	43					○			
						780							
						770							
			13	SS	44					○			
757.3						760							
93.0	Sandy silt, some gravel and clay.												
	Very Dense		14	SS	62/1"	750	bouncing			○			
746.3													

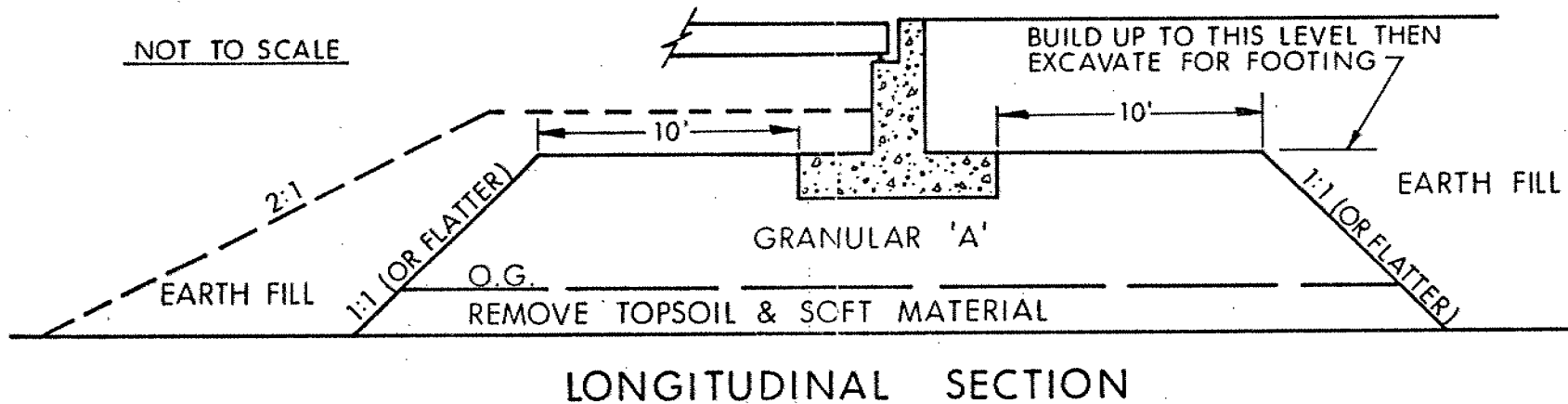
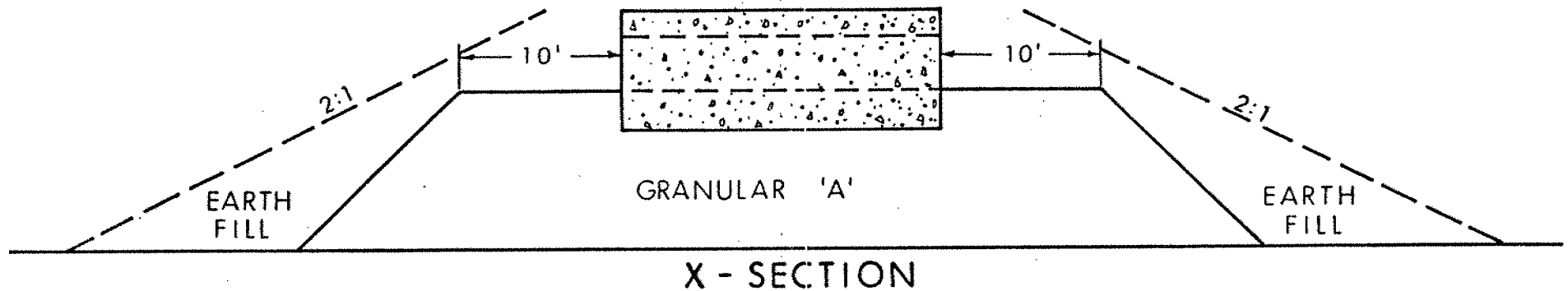
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RECORD OF BOREHOLE NO 3 Continued

WP 41-66-06 LOCATION Co-ords. 15,591,022 N; 1,336,962 E. ORIGINATED BY RD
 DIST 2 HWY 402 BORING DATE Aug. 11-13, 1975 COMPILED BY RD
 DATUM Geodetic BOREHOLE TYPE Hollow Stem Augers CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT					LIQUID LIMIT w_L PLASTIC LIMIT w_P WATER CONTENT w			UNIT WEIGHT γ	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100	w_P	w	w_L		
746.3	Continued															
104.0	Sandy silt, some gravel and clay.		15	SS	120/4"											
739.5	Very Dense		16	SS	100/4" 740											14 37 38 11
110.8	End of Borehole															

ABUTMENT ON COMPACTED FILL SHOWING GRANULAR 'A' CORE



NOTES

- 1 - REMOVE TOPSOIL &/OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A'.
- 2 - PLACE GRANULAR 'A' TO TOP OF FOOTING LEVEL, COMPACTED ACCORDING TO CURRENT M.T.C. STANDARDS.
- 3 - EXCAVATE COMPACTED GRANULAR 'A' MATERIAL FOR FOOTING.

ABBREVIATIONS & SYMBOLS USED IN THIS REPORTPENETRATION RESISTANCE

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

TERMS TO BE USED IN DESCRIBING SOILS:-

TRACE < 10% , SOME 10-25% , WITH 25-40% , > 40% SILTY, SANDY, GRAVELLY, CLAYEY ETC.

TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.T.	SLOTTED TUBE SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE

P.H. SAMPLE ADVANCED HYDRAULICALLY

P.M. SAMPLE ADVANCED MANUALLY

SOIL TESTS

U	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
UU	UNCONSOLIDATED UNDRAINED TRIAXIAL	F.V.	FIELD VANE
CIU	CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL	C	CONSOLIDATION
CID	" " DRAINED "	S	SENSITIVITY
CAU	" ANISOTROPIC UNDRAINED "		
CAD	" " DRAINED "		

ABBREVIATIONS & SYMBOLS USED IN THIS REPORTSOIL 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
w_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 INTERCEPT
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_t	SENSITIVITY

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

STRESS AND STRAIN

u'	PORE PRESSURE
σ	NORMAL STRESS
σ'	NORMAL EFFECTIVE STRESS ($\bar{\sigma}$ IS ALSO USED)
τ	SHEAR STRESS
ϵ	LINEAR STRAIN
γ	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

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

