

66-F-37

W.P. # 636-64

KITCHENER -

WATERLOO

EXPRESSWAY

ε C.N.R.

MEMORANDUM

GEN. FILES

w.P. 636-64.

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

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

Attention: Mr. S. McCombie

DATE: July 4, 1966

OUR FILE REF.

IN REPLY TO

JUL 19 1966

SUBJECT:

FOUNDATION INVESTIGATION REPORT
For
C.N.R. Subway
Kitchener-Waterloo Expressway
District #4 (Hamilton)
W.J. 66-F-37 -- W.P. 636-64

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

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

AGS/MdeF
Attach.

cc: Messrs. B. R. Davis (2)
H. A. Tregaskes
D. W. Farren
A. Gater
H. Greenland
J. Roy
W. S. Melinyshyn
W. L. Bradley
A. D. Margison Ltd.
University of Waterloo

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

Foundations Office
Gen. Files

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FOUNDATION INVESTIGATION REPORT
For
Kitchener-Waterloo Expressway
District #4 (Hamilton)
W.J. 66-F-37 -- W.P. 636-64

1. INTRODUCTION:

A foundation investigation at the site of the proposed crossing of the C.N.R. and the Kitchener-Waterloo Expressway was requested by the Bridge Planning Section. This request was contained in a memo from Mr. W. S. Melinyshyn, Regional Bridge Location Engineer, dated April 15, 1966.

A field investigation was subsequently carried out by this Section to determine the subsoil conditions existing at the site.

This report contains the results of field and laboratory investigations, together with recommendations pertaining to the foundations for the new bridge and the stability of the proposed embankments.

2. DESCRIPTION OF SITE:

The site is located some 3/4 mile west of the east boundary of Kitchener City Limits, about 500 feet north of Hwy. #7. The area in the vicinity of the site is gently sloping apart from the existing 20-foot high railway embankment.

Physiographically, the site is located in the region referred to as the "Waterloo Hills." Soils in this region are mainly well drained, glacio-fluvial deposits.

3. FIELD WORK:

A total of 23 borings and 14 dynamic cone penetration tests was carried out during the course of the field work. Boring was achieved by means of conventional diamond drilling equipment

3. FIELD WORK: (cont'd.) ...

adapted for soil sampling purposes. Samples were recovered at required depths using standard split-spoon samplers. The latter were driven into the soil with a 140-lb. hammer imparting an energy of 350 foot-lbs. per blow.

The borings were staked out and surveyed in the field by personnel from A. D. Margison and Associates. The locations and elevations of the boreholes are shown on Drawing #66-F-37A, which is contained in the Appendix of this report.

4. LABORATORY TESTING:

All samples were subjected to a careful visual examination in the laboratory. Tests were then carried out on selected samples primarily for classification purposes. The results of these tests are summarized on the Record of Borelog sheets which are contained in the report Appendix. Tests were carried out to define the following physical properties:

Atterberg Limits
Moisture Content
Grain-Size Distribution

5. SOIL TYPES AND SOIL CONDITIONS:

5.1) General:

Subsoil at the site consists of generally shallow deposits of muck overlying silty sand, clayey silt and silty clay. Over most of the area, conditions are fairly uniform below the surface deposits. The boundaries between the different soil strata are shown on the borelog sheets contained in the Appendix of the report. The estimated stratigraphical profiles shown on Drawing #66-F-37A, are based upon this information. A description of the different soil types encountered in the boreholes, follows:

cont'd. /3 ...

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

5.2) Fill Material (Rubble and Organics):

About 8 feet of fill material, consisting of a mixture of rubble and organic material, was observed in B.H. #13 only.

5.3) Muck:

A deposit of muck overlies most of the site area. The depth ranges from about 1 foot to about 10 feet. Where the depth is greater than about 3 feet, the lower portions contain varied amounts of silt, sand and gravel.

5.4) Silty Sand:

This deposit was found at the location of the proposed railway detour in Boreholes 1A - 8A, inclusive, and 12A - 16A, inclusive. The maximum observed depth was 22 feet in B.H. 6A. The material consists of about 80 - 90% sand-sized particles, the remainder being mostly silt. The average moisture content is about 10%. 'N' values obtained from Standard Penetration tests ranged from about 14 to more than 100 blows per foot, indicating a compact to very dense relative density.

5.5) Clayey Silt to Silty Clay:

This is the predominant soil deposit at the site and extends for a depth of at least 42 feet to El. 998.0. The deposit is essentially a cohesive soil ranging in degree of plasticity from low to intermediate. The material accordingly is classified as clayey silt (CL) to silty clay (CI). Because of the hardness of the soil, split-spoon samples only, were recovered during boring operations. 'N' values obtained from Standard Penetration tests ranged from 18 to 135 blows/ft., indicating an overall stiff to hard consistency. Based on these 'N' values, the undrained shear strength is estimated to range from 2000 - 12,000 p.s.f. Mechanical analyses indicated the following grain-size distribution: gravel - 1%, sand - 10%, silt - 47%, clay - 42%. Atterberg limit tests are summarized as follows:

cont'd. /4 ...

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

5.5) Clayey Silt to Silty Clay: (cont'd.) ...

	<u>Max.</u>	<u>Min.</u>	<u>Average</u>
Liquid Limit	44	22	33
Plastic Limit	23	15	17

The moisture content within this deposit was found to be generally close to the plastic limit.

6. GROUNDWATER CONDITIONS:

Groundwater level in the borings was found to be generally 2 to 3 feet below the ground surface over most of the area. In the high ground at the proposed detour location west of B.H. 8A, the water level averaged about 10 feet below the surface.

7. DISCUSSION AND RECOMMENDATIONS:

It is proposed to construct a subway at this site. At present, a 6-span structure some 320 ft. long is contemplated. The existing grade of the C.N.R. will be maintained at its present level of 1070.0 ± and the grade of the new expressway will be such that the maximum fill height of the railway embankment will be about 25 feet. During construction of the subway, the C.N.R. will be detoured to the north and for this purpose, a temporary embankment having a maximum height of about 30 feet and a total length of about 1700 feet, will be constructed. Various aspects of the project are discussed separately below.

7.1) Structure:

Subsoil conditions at the site are such that adequate support for spread footing type foundations can be obtained in the very stiff to hard clayey silt to silty clay layer. It is recommended, therefore, to found the various footings at the

cont'd. /5 ...

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

7.1) Structure: (cont'd.) ...

elevations shown below, assuming a design pressure of 3.0 t.s.f. For identification purposes, the proposed piers are numbered 1 - 5 from west to east.

West Abutment	El. 1040.0
Pier #1	El. 1034.0
Pier #2	El. 1034.0
Pier #3	El. 1034.0
Pier #4	El. 1034.0
Pier #5	El. 1034.0
East Abutment	El. 1034.0

As an alternative, if perched abutments are decided upon, they may be constructed within the approach fills and supported on large displacement piles. In this event, it is estimated that either 12-3/4" O.D. steel tubes of 12" \emptyset concrete piles driven to approximate elevation 1020.0, should achieve a design capacity of 50 tons/pile. If the above recommendations are followed, it is believed that differential settlements will be of a negligible order only.

7.2) Dewatering of Excavations:

Subsoil below the recommended footing elevations consists generally of relatively impermeable cohesive deposits, in which case no major dewatering problems are anticipated. In the vicinity of the east and west abutments and piers #1 and #2, it is possible that some silt deposits will be encountered, and at these locations a dewatering scheme utilizing steel sheet piling, may be required. This can best be determined at the time of construction.

cont'd. /6 ...

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

7.3) Structure Approaches and Proposed Detour:

At the locations of the proposed detour and structure approaches, surface organic deposits exist over a large area. It is recommended that these deposits be removed prior to placing fill material. In this event, no stability problems are anticipated for the proposed embankments. It is recommended also, that further field work be carried out by the Soils Section to determine the full extent of the organic deposits.

8. SUMMARY:

A foundation investigation at the site of the proposed C.N.R. and Kitchener-Waterloo Expressway crossing is reported.

Subsoil at the site consists of soft organic deposits, compact to very dense sandy silt deposits and very stiff to hard cohesive deposits of silty clay and clayey silt.

It is recommended to found the new structure on spread footings placed within the very stiff to hard cohesive deposits utilizing a safe design pressure of 3.0 t.s.f. In the event that perched abutments are decided upon, these may be supported on large displacement steel or precast concrete piles.

Design loads of 50 tons/pile are recommended for 12-3/4" O.D. steel or 12" \emptyset precast concrete piles driven to approximate elevation 1020.0.

Generally speaking, no major dewatering problems are anticipated except at the locations of the west abutment and piers #1 and #2. At these latter locations, precautions may be necessary to prevent 'boiling' of the excavation bases.

No stability problems are anticipated for the proposed detour and structure approach embankments, provided all organic deposits below the proposed fills are removed.

cont'd. /7 ...

9. MISCELLANEOUS:

The field work for this project was carried out by Johnston Drilling Co. Ltd. under the supervision of Mr. W. W. Kulmatickas, Project Foundation Engineer.

The investigation took place during the period April 25 to May 13, 1966.

This report was prepared by Mr. K. G. Selby, Supervising Foundation Engineer.

July 1966

APPENDIX I

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO.1

FOUNDATION SECTION

JOB 66-F-37 LOCATION N202, 281.476; E 210, 750.638 ORIGINATED BY W.W.K.
 W.P. 636-64 BORING DATE May 3, 1966 COMPILED BY W.E.
 DATUM 1052.65 BOREHOLE TYPE Washboring NX Casing CHECKED BY dlr

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	NUMBER	TYPE	BLOWS / FOOT		20	40	60	80	100	WP	W	WL		
1052.65	Ground Level														
1048.6	Muck Soft				1050										
4.0	Sand Clayey Silt with some Gravel Very Stiff to Hard	1	SS	30											
1039.6		2	SS	56	1040										
13.0	Clayey Silt to Silty Clay with traces of Sand Hard	3	SS	77											
		4	SS	62	1030										
		5	SS	49											
		6	SS	57	1020										
		7	SS	46	1010										
1001.15		8	SS	61											
51.5	End of Borehole				1000										

W.L. El. 1051.3
 Observed in Casing
 Gravel 10%
 Sand 34%
 Silt 37%
 Clay 19%

 Sand 8%
 Silt 60%
 Clay 32%

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 4

FOUNDATION SECTION

JOB 66-F-37 LOCATION N 202,459.731; E210,853.370 ORIGINATED BY W.W.K.
 W.P. 636-64 BORING DATE May 5, 1966 COMPILED BY W.E.
 DATUM 1043.16 BOREHOLE TYPE Washboring NX Casing CHECKED BY ll

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		BLOWS / FOOT	20	40	60	80	100	WP	W		
1043.16	Ground Level															
1039.1	Muck Soft					1040										
4.0	Silty Clay with Traces of Sand Stiff to Hard		1	SS	26											
			2	SS	80											
			3	SS	26											
			4	SS	52											
			5	SS	53											
			6	SS	62											
			7	SS	68											
1001.66			8	SS	135											
41.5	End of Borehole					1000										

W.L. El. 1041.7
 Observed in Casing
 Sand 6%
 Silt 44%
 Clay 50%

Sand 10%
 Silt 39%
 Clay 51%

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION
RECORD OF BOREHOLE NO. 4A
 FOUNDATION SECTION

JOB 66-F-37 LOCATION N 202,305.245 ; E 210,484.450 ORIGINATED BY W.W.K.
 W.P. 636-64 BORING DATE May 13, 1966 COMPILED BY W.E.
 DATUM 1068.28 BOREHOLE TYPE Washboring NX Casing CHECKED BY HL

SOIL PROFILE		SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W WP — W — WL WATER CONTENT % 10 20 30	BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		BLOWS / FOOT	BLOWS / FOOT						
1068.28	Ground Level												
1067.28	Black Org. Topsoil												
1.0	Silty Sand Compact to V. Dense		1	SS	23	1060							Observed in Casing W.L. El. ▼1060.2 Sand 90% Silt 10% Clay
1056.7			2	SS	83								
11.5	End of Borehole					1050							

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 5

FOUNDATION SECTION

JOB 66-F-37 LOCATION N 202,324.399 ; E 210,831.709 ORIGINATED BY W.W.K.
 W.P. 636-64 BORING DATE May 3, 1966 COMPILED BY W.E.
 DATUM 1044.85 BOREHOLE TYPE Washboring NX Casing CHECKED BY [Signature]

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — WL PLASTIC LIMIT — WP			BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT	20	40	60	80	100	WP	W		
1044.85	Ground Level															
1041.8	Muck Soft															
3.0	Silt to Clayey Silt		1	SS	36	1040							○			
	Hard		2	SS	64									○		
			3	SS	52	1030								○		
1024.3			4	SS	63									○		
20.5	Silty Clay		5	SS	62	1020								○		
	Hard		6	SS	67	1010								○		
			7	SS	84	1000								○		
998.35																
45.5	End of Borehole															

W.L. EL. 1043.6
 Observed in Casing
 Sand 14%
 Silt 80%
 Clay 6%

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 5A

FOUNDATION SECTION

JOB 66-F-37 LOCATION N 202,356.975 ; E 210,569.960 ORIGINATED BY W.W.K.
 W.P. 636-64 BORING DATE May 11, 1966 COMPILED BY W.E.
 DATUM 1061.73 BOREHOLE TYPE Washboring NX Casing CHECKED BY SL

SOIL PROFILE			SAMPLES			ELEV. SCALE	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		SHEAR STRENGTH P.S.F.				WP — W — WL ----- ----- 10 20 30 WATER CONTENT %				
1061.73	Ground Level														
1060.23	Black Org. Topsoil	<i>~</i>				1060									
1.5	Silty Sand Loose to V. Dense	<i>· · · · ·</i>	1	SS	3										
			2	SS	96	1050									
			3	SS	114										
1040.2			4	SS	156	1040									
21.5	End of Borehole														
						1030									

W.L. El.
 ▼ 1053.2
 Observed in
 Casing
 Gravel 4%
 Sand 88%
 Silt 7%
 Clay

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO.8

FOUNDATION SECTION

JOB 66-F-37 LOCATION N 202,497.114 ; E 210,938.122 ORIGINATED BY W.W.K.
 W.P. 636-64 BORING DATE May 5, 1966 COMPILED BY W.E.
 DATUM 1043.04 BOREHOLE TYPE Washboring NX Casing CHECKED BY JK

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		BLOWS / FOOT	20	40	60	80	100	WP	W		
1043.04	Ground Level															
1039.5	Muck Soft					1040										
3.5	Silty Clay with Traces of Sand Stiff to Hard		1	SS	18											
			2	SS	41											
			3	SS	44	1030										
			4	SS	45											
			5	SS	25	1020										
			6	SS	43											
			7	SS	34	1010										
						1000										
996.54			8	SS	104											
46.5	End of Borehole															

W.L. El.
1041.5
Observed in
Casing

Gravel 1%
Sand 2%
Silt 34%
Clay 63%

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 8A

FOUNDATION SECTION

JOB 66-F-37 LOCATION N202,485.565 ; E 210,838.988 ORIGINATED BY W.W.K.
 W.P. 636-64 BORING DATE May 11, 1966 COMPILED BY W.T.E.
 DATUM 1041.76 BOREHOLE TYPE Washboring NX Casing CHECKED BY [Signature]

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE				LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W	BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT						
1041.76	Ground Level												
1039.76	Black Org. Topsoil					1040							
2.0	Silty Clay with Traces of Sand and occ. Gravel		1	SS	27								
	Very Stiff to Hard		2	SS	42	1030							
1025.2			3	SS	77								
16.5	End of Borehole					1020							

1040.6
 W.L. El.
 Observed in Casing
 Sand 2%
 Silt 47%
 Clay 51%

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 9

FOUNDATION SECTION

JOB 66-F-37 LOCATION N 202.376.404 ; E 210.937
 W.P. 636-64 BORING DATE May 2, 1966
 DATUM 1045.02 BOREHOLE TYPE Washboring NX Casing

ORIGINATED BY W.W.K.
 COMPILED BY W.E.
 CHECKED BY [Signature]

SOIL PROFILE		SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT 20 40 60 80 100 SHEAR STRENGTH P.S.F.	LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W WP — W — WL WATER CONTENT %	BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE					
1045.02	Ground Level								
0.0	Muck Soft	[Wavy Pattern]							
1036.0			1	SS	2			69%	
9.0	Clayey Silt with Traces of Gravel and Sand Very Stiff to Hard	[Diagonal Hatching]	2	SS	21				
			3	SS	26			Gravel 3% Sand 17% Silt 56% Clay 24%	
			4	SS	64				
			5	SS	98			Gravel 11% Sand 13% Silt 60% Clay 16%	
			6	SS	69				
998.52			7	SS	76				
46.5	End of Borehole								

▽ 1043.9
W.L. El.
Observed in
Casing

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 9A

FOUNDATION SECTION

JOB 66-F-37 LOCATION N 202,536.090 ; E 210,925.818 ORIGINATED BY W.W.K.
 W.P. 636-64 BORING DATE May 10, 1966 COMPILED BY W.E.
 DATUM 1040.88 BOREHOLE TYPE Washboring 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 P.C.F.	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.					WP	W	WL			
1040.88	Ground Level																
1039.38	Black Org. Topsoil	[Hatched]				1040											
1.5	Clayey Silt with Traces of Sand and occ. Gravel Very Stiff to Hard	[Hatched]	1	SS	31												
			2	SS	57	1030											
			3	SS	64												
1024.3	End of Borehole					1020											
16.5						1010											

▼ 1039.4
 -W.L. El.
 Observed in
 Casing
 Sand 5%
 Silt 57%
 Clay 38%

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 10A

FOUNDATION SECTION

JOB 66-F-37 LOCATION N 202,583.607 ; E 211,016.125 ORIGINATED BY W.W.K.
 W.P. 636-64 BORING DATE May 10, 1966 COMPILED BY W.T.E.
 DATUM 1043.63 BOREHOLE TYPE Washboring NX Casing CHECKED BY SK

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W WP — W — WL WATER CONTENT % 10 20 30	BULK DENSITY P.C.F.	REMARKS	
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT								SHEAR STRENGTH P.S.F.
1043.63	Ground Level														
1041.63	Black Org. Topsoil					1040									
2.0	Clayey Silt with some Sand and Traces of Gravel		1	SS	24										
	Very Stiff to Hard		2	SS	41	1030									
1027.1			3	SS	68										
16.5	End of Borehole					1020									
						1010									

▼ 1041.4
W.L. El.
Observed in Casing
Gr. 4%
Sa. 13%
Si. 57%
Cl. 26%

DEPARTMENT OF HIGHWAYS - ONTARIO

RECORD OF BOREHOLE NO. 12

FOUNDATION SECTION

MATERIALS & TESTING DIVISION

JOB 66-F-37

LOCATION N 202,546.057 ; E211,038.933

ORIGINATED BY W.W.K.

W.P. 636-64

BORING DATE May 6, 1966

COMPILED BY W. E.

DATUM 1045.43

BOREHOLE TYPE Washboring NX Casing

CHECKED BY [Signature]

SOIL PROFILE		STRAT. PLOT	SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE				LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W	BULK DENSITY γ _{p.c.f.}	REMARKS		
ELEV. DEPTH	DESCRIPTION		NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT	20	40	60				80	100
1045.43	Ground Level														
1042.9 2.5	Black Org. Topsoil														
	Clayey Silt to Silty Clay with traces of Sand		1	SS	34	1040									
	Very Stiff to Hard		2	SS	27										
			3	SS	65	1030									
			4	SS	93										
			5	SS	102	1020									
			6	SS	70										
			7	SS	63	1010									
998.93 46.5	End of Borehole		8	SS	87	1000									

W.L. El. 1043.2
 Observed in Casing
 Gravel 4%
 Sand 19%
 Silt 53%
 Clay 24%

Gravel 1%
 Sand 6%
 Silt 68%
 Clay 25%

DEPARTMENT OF HIGHWAYS - ONTARIO

RECORD OF BOREHOLE NO. 12A

FOUNDATION SECTION

MATERIALS & TESTING DIVISION

JOB 66-F-37 LOCATION N 202,654.890 ; E 211,201.213 ORIGINATED BY W.W.K.
 W.P. 636-64 BORING DATE May 10, 1966 COMPILED BY W.T.E.
 DATUM 1050.41 BOREHOLE TYPE Washboring NX Casing CHECKED BY JK

SOIL PROFILE			SAMPLES			ELEV. SCALE	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		SHEAR STRENGTH P.S.F.				WATER CONTENT % WP — W — WL 10 — 20 — 30					
1050.41	Ground Level															
1047.11	Black Org. Topsoil															
3.3	Silty Sand		1	SS	25											
1043.41	Compact															
7.0	Clayey Silt with some Sand and traces of Gravel.			2	SS	57	1040									
1033.9	Hard		3	SS	78											
16.5	End of Borehole					1030										
						1020										

W.L. El.
▼ 1046.7
Observed in Casing
Gr. 2%
Sa. 12%
Si. 52%
Cl. 34%

DEPARTMENT OF HIGHWAYS - ONTARIO

RECORD OF BOREHOLE NO.14

FOUNDATION SECTION

MATERIALS & TESTING DIVISION

JOB 66-F-37

LOCATION N 202,565.448 ; E 211,080.483

ORIGINATED BY W.W.K.

W.P. 636-64

BORING DATE May 6, 1966

COMPILED BY W.E.

DATUM 1045.49

BOREHOLE TYPE Penetration Only

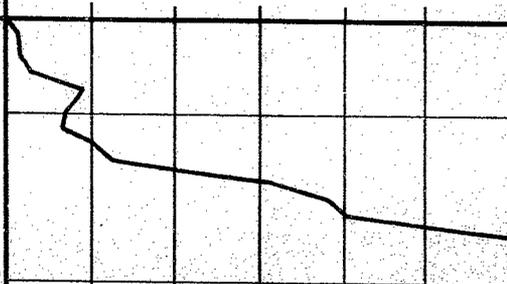
CHECKED BY JR

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE					LIQUID LIMIT — WL			BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT	20	40	60	80	100	PLASTIC LIMIT — WP	WATER CONTENT — W		
1045.49	Ground Level															
0.0	Penetration Only					1040										
1033.49																
12.0	End of Borehole					1030										

DYNAMIC PENETRATION RESISTANCE
BLOWS / FOOT
20 40 60 80 100
SHEAR STRENGTH P.S.F.

LIQUID LIMIT — WL
PLASTIC LIMIT — WP
WATER CONTENT — W
WP — W — WL
WATER CONTENT %

BULK DENSITY
P.C.F.



DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING DIVISION

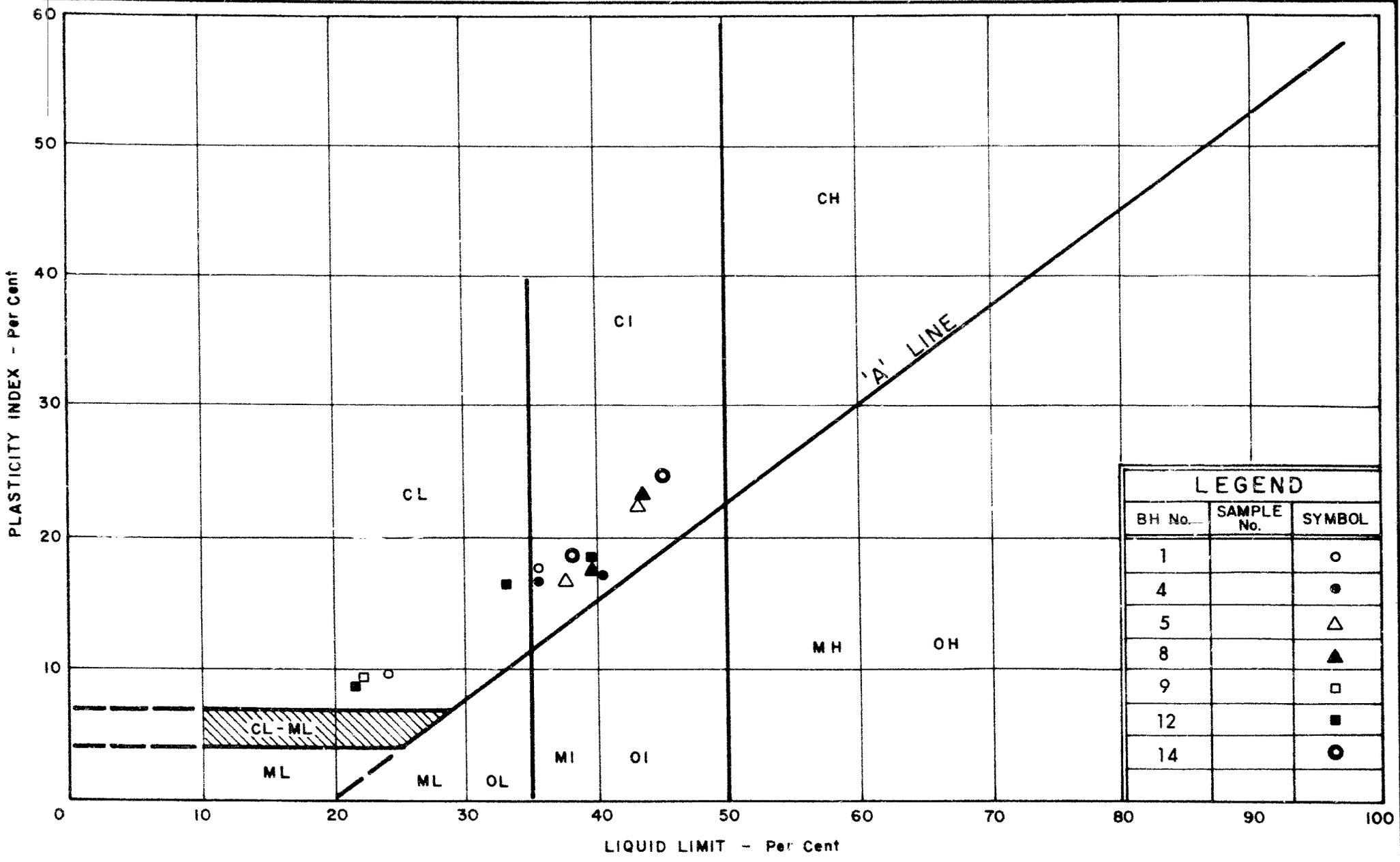
RECORD OF BOREHOLE NO. 16A

FOUNDATION SECTION

JOB 66-F-37 LOCATION N 202,783.026 ; E 211,577.289 ORIGINATED BY W.W.K.
 W.P. 636-64 BORING DATE May 9, 1966 COMPILED BY W.T.E.
 DATUM 1056.47 BOREHOLE TYPE Washboring NX Casing CHECKED BY [Signature]

ELEV. DEPTH	SOIL PROFILE DESCRIPTION	STRAT. PLOT	SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT				LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W			BULK DENSITY P.C.F.	REMARKS	
			NUMBER	TYPE	BLOWS / FOOT		SHEAR STRENGTH P.S.F.				WP	W	WL			
1056.47	Ground Level															
0.0																
1053.47	Black Org. Top Soil	[Wavy Pattern]														
3.0	Silty Sand with traces of Clay and Gravel	[Dotted Pattern]	1	SS	20	1050										
			2	SS	33											
	Compact to V. Dense		3	SS	57											
			4	SS	74		1040									
1038.47	Clayey Silt with some Sand - Hard	[Diagonal Pattern]	5	SS	126		10*									
1034.97																
21.5	End of Borehole															
						1030										
						1020										

W.L. El. ∇ 1049.4
 Cr. 2%
 Sa. 57%
 Si. 37%
 Cl. 4%
 Observed in Casing



LEGEND		
BH No.	SAMPLE No.	SYMBOL
1		○
4		●
5		△
8		▲
9		□
12		■
14		⊙



PLASTICITY CHART

W.P. No. 636-64
 JOB No. 66-F-37

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

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 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

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ROBERT A. CUNNINGHAM, B. SC., P. ENG. SUPERVISION OF CONSTRUCTION

19th May, 1966

Mr. K.G. Selby, P. Eng.,
Supervising Foundation Engineer,
Department of Highways Ontario,
Downsview, Ontario

Re: Kitchener-Waterloo Expressway
W. P. 636-64, C.N.R. Subway
W. P. 637-64, Wellington Street Underpass
Our Projects Nos. 2119-51 and 2123

Dear Sir:

Enclosed herewith please find tables listing
elevations and coordinates for boreholes on the above projects.

Yours very truly,

A. D. MARGISON AND ASSOCIATES LIMITED

Encls.
GS:dk



G. Solty, P. Eng.

A. D. Margison and Associates Limited
 Consulting Professional Engineers

W.P. 636-64 Kitchener-Waterloo Expressway
 C.N.R. SUBWAY
 Project No. 2119-51

Borehole No.	Elevation	North Coordinate	EAST- South Coordinate	
2	1052.28	202,428.668	210,788.941	North Side
4	1043.16	202,459.731	210,853.370	
6	1041.90	202,483.115	210,897.822	
8	1043.04	202,497.114	210,938.122	
10	1043.63	202,520.538	210,984.640	
12	1045.43	202,546.057	211,038.933	
14	1045.49	202,565.448	211,080.483	
1	1052.65	202,281.476	210,750.638	South Side
3	1048.06	202,313.976	210,790.670	
5	1044.85	202,324.399	210,831.709	
7	1044.77	202,358.827	210,890.628	
9	1045.02	202,376.404	210,937.956	
11	1047.23	202,400.356	210,983.633	
13	1054.46	202,439.340	211,087.105	

A. D. Margison and Associates Limited
 Consulting Professional Engineers

W.P. 636-64 Kitchener-Waterloo Expressway
 C.N.R. DETOUR
 Project No. 2119-51

Borehole No.	Elevation	North Coordinate	South EAST Coordinate
1 A	1076.47	202,157.733	210,229.947
2 A	1075.10	202,193.911	210,317.885
3 A	1070.88	202, 243.57 ^{243.57}	210, 332.174 ^{332.174}
4 A	1068.28	202,305.245	210,484.450
5 A	1061.73	202,356.975	210,569.960
6 A	1059.09	202,399.565	210,618.220
7 A	1053.17	202,454.512	210,743.057
8 A	1041.76	202,485.565	210,838.988
9 A	1040.88	202,536.090	210,925.818
10 A	1043.63	202,583.607	211,016.125
11 A	1046.54	202,622.339	211,106.332
12 A	1050.41	202,654.890	211,201.213
13 A	1051.75	202,683.675	211,295.186
14 A	1052.95	202,715.647	211,392.946
15 A	1054.26	202,743.706	211,489.961
16 A	1056.47	202,783.026	211,577.289