G.I.-30 SEPT. 1976

GEOCRES No. 40J16-61

DIST. 1 REGION

W.P. No. 254-91-05

CONT. No.

W. O. No.

STR. SITE No. 14-290/2

HWY. No. 40

LOCATION Hwy 40 & CNR Overhead S.B.L.

No of PAGES - —

OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.

REMARKS:

Ministry
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Transportation
Ontario

FILE No. _____ **DATE** _____

REMARKS GEOCRES No 40J16-13

ADM-G-24 91-02

ENGINEERING MATERIALS OFFICE
FOUNDATION DESIGN SECTION

WP	254-91-05	DIST	1
HWY	40	STR SITE	14-290/2

CNR Overhead Southbound Lanes

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GEOCRES 40J16-61

DATE OCT 12 1994

FOUNDATION INVESTIGATION REPORT

FOR

CNR Overhead Southbound Lanes

W.P. 254-91-05, Site 14-290/2

Highway 40, District 1, Chatham

INTRODUCTION

The foundation investigation for both southbound and northbound lanes at the crossing of Highway 40 and CN Railway was carried out in February, 1963 under W.P. 53-63. The subsoil information contained in this report was obtained from this investigation and no additional boreholes were advanced at the location of the proposed southbound lanes overhead structure.

SITE DESCRIPTION

The site is located at the crossing of Hwy. 40 and CN Railway in the City of Sarnia, County of Lambton.

The topography of the site with the exception of the existing crossing (embankment fill) is generally flat. Physiographically, the area is located in the region known as the "St. Clair Clay Plain". Adjoining the St. Clair River in Lambton county are extensive clay plains covering several hundred square kilometres. The subsoil at this site is a clayey material deposited during the Wisconsin glacial stage of the Pleistocene Epoch. The bedrock underlying the clayey soil is a black shale of Devonian and Missipian Age.

SUBSURFACE CONDITIONS

General

The subsoil at this site consists of about 2.7 m to 9.9 m clayey fill underlain by 9.2 m to 13.7 m

hard to stiff clayey silt with sand and gravel. The clayey silt deposit is underlain by 23.2 m to 26.2 m very stiff to stiff silty clay which overlies black shale bedrock at a depth of about 36.7 m to 37.2 m below the existing ground level. For classification purposes, the soils encountered at this site can be divided into four different zones.

a) Clayey Silt to Silty Clay (Fill)
b) Clayey Silt with Sand and Gravel
c) Silty Clay with Sand and Gravel
d) Shale Bedrock

The subsurface conditions encountered during the course of the investigation, together with the field and laboratory test results are shown on the Record of Borehole Sheets contained in the Appendix of this report. A stratigraphical section is shown on Drawing No. 2549105-A. This drawing also shows the locations and elevations of the borings. Description of the strata encountered are given below.

a) Clayey Silt to Silty Clay (Fill)

This approach fill consists of clayey silt to silty clay with varying proportion of sand, boulders and cinders. The thickness of this fill varies from 2.7 m to a maximum of 9.9 m and extends to elevation 186.1. The moisture content varies from 9% to 24%. The Standard Penetration Test values (4 blows/0.3 m to 24 blows/0.3 m) vary over a wide range and indicate soft to very stiff consistency.

b) Clayey Silt with Sand and Gravel

The clayey fill is underlain by this clayey silt deposit with varying proportions of sand and gravel.

The thickness of this deposit varies from 9.2 m to 13.7 m and extends to elevations 176.9 to 173.8. The natural moisture content varies from 9% to 23% with an average value of 18.2%. The Atterberg Limits determined for the representative samples of this deposit are shown on Figure 1. The in-situ Vane Shear Test results vary from in excess of 100 kPa in the upper crust to a minimum of 46 kPa at about elevation 179. However, the unconfined compression strength varies from a minimum of 29 kPa to a maximum of 73 kPa. The Standard Penetration Test values vary over a wide range (14 blows/0.3 m to 42 blows/0.3 m). Based on these test results, this deposit may be classified as hard to stiff consistency.

c) Silty Clay with Sand and Gravel

The clayey silt is underlain by this silty clay with varying proportions of sand and gravel. The thickness of this deposit varies from 23.2 m to 26.7 m and extends to elevations 150.8 to 150.6. The natural moisture content varies from 14% to 27% with an average value of 21.8%. The Atterberg Limit Test results for this deposit are shown on Figure 2. The Unconfined Compression Test carried out on undisturbed samples indicate shear strength in excess of 100 kPa to a minimum of 45 kPa. Based on limited field and laboratory test results, this deposit may be classified as very stiff to stiff consistency.

d) Shale Bedrock

The bedrock was proved only in two boreholes by coring and was found to be a black shale. The bedrock at this site was encountered at about elevations 150.8 to 150.6. No evidence of surface weathering was observed in the recovered core. The bedrock at this site may be classified as unweathered black shale of Kettle Point Formation.

Groundwater Conditions

It appears that the groundwater was encountered in all the boreholes, with the exception of

borehole 6. The groundwater level in each borehole is as follows:

Borehole No.	Elevation	Remarks
1	186.4	
2	185.9	
3	186.4	
4	182.6	
5	181.4	
6	-	Not Established

DISCUSSION AND RECOMMENDATIONS

General

In order to accommodate the upgrading of Highway 40, it is proposed to construct a new overhead structure for southbound lanes at the crossing of Hwy. 40 and CN Railway. The new bridge will twin the existing overhead structure which will serve as the future northbound lanes.

The proposed bridge will be a four span prestressed concrete beam structure with 13.0 m end span on the north side and on the south side, the end span will be 16.0 m. The centre span on the south side will be about 28.0 m and on the north side, it will be approximately 23.0 m. The finished grade of the southbound lanes will be set approximately 60 mm to 100 mm higher than the existing lanes.

The existing bridge (future N.B.L.) is a four span simply supported concrete structure with 13.7 m end spans. The centre span on the south side is approximately 1.7 m longer than that on the north side and the spans are 23.0 m and 21.3 m, respectively. The approach embankments as well as the structure appear in very good condition. However, it appears that rehabilitation work was carried out recently and also, spalling of concrete from the deck has been noticed at one location.

Based on the information available in this office, the piers for the existing structure is supported on approximately 3.0 m wide footings placed at about elevation 185.9 and the abutments are supported on 324 mm O.D., 5 mm thick tube piles filled with concrete. These piles are founded at about elevation 184.4.

Structure Foundation

Considering the subsoil conditions at this site, it is recommended that the piers be supported on spread footings placed at about elevation 185.9. The following bearing capacity values are recommended for the design of the footings.

Factored Bearing Capacity at U.L.S. = 350 kPa
Bearing Capacity at S.L.S. = 200 kPa

The allowable bearing pressure (S.L.S.) recommended above is expected to induce settlement in the order of 25 mm to 40 mm.

The abutments may be supported on short 324 mm diameter closed end steel tube piles driven to about elevation 184.4. The following pile capacity values may be used for the design.

Factored Axial Capacity at U.L.S = 320 kN
Axial Capacity at S.L.S. =270 kN

Alternatively, the piers and abutments may be supported on steel H-piles driven to bedrock, which will be encountered at about El. 150.5±. The following pile capacity values are recommended for the design.

	HP 310 X 110	HP 310 X 79
Factored Axial Capacity at U.L.S.	1600 kN	1150 kN
Axial Capacity at S.L.S.	1150 kN	900 kN

Lateral Earth Pressure

Earth pressure should be computed as per Section 6.7.4.5 of the O.H.B.D.C., and the coefficient of earth pressure at rest shall be used for rigid and unyielding wall. The Granular "A" or "B" backfill should be in accordance with the Special Provision No. 109F03. The following parameters are recommended for the granular backfill.

	Granular "A"	Granular "B"
Angle of Internal Friction	$\phi = 35°$	$\phi = 30°$
Unit Weight (kN/m^3)	$\gamma = 22.8$	$\gamma = 21.2$

If the piers are supported on spread footings, the sliding resistance may be estimated based on effective angle of internal friction neglecting the effective shear strength of the founding soil. An unfactored coefficient of friction value of tan 26° may be assumed for the estimate.

Approach Embankment

The finished grade of the southbound lanes will be set approximately 60 mm to 100 m (ie. El. 196.6) higher than the grade of the existing lanes. This will result in a fill height of about 8.0 m above the existing ground level. The approach fill for the southbound lanes was placed about thirty (30) years back. No major settlement or stability problems are anticipated, if the raise of finish grade is limited to about 1.0 m.

Other Considerations

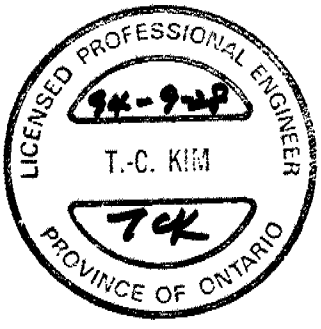
The pile caps should have a minimum of 1.2 m earth cover to protect against frost penetration.

The base of the excavation at the founding level should be covered with 150 mm thick lean concrete pad upon exposure to avoid any deterioration.

MISCELLANEOUS

This report was prepared by M. Vasavithasan, Foundation Engineer, reviewed by Tae C. Kim, Senior Foundation Engineer.

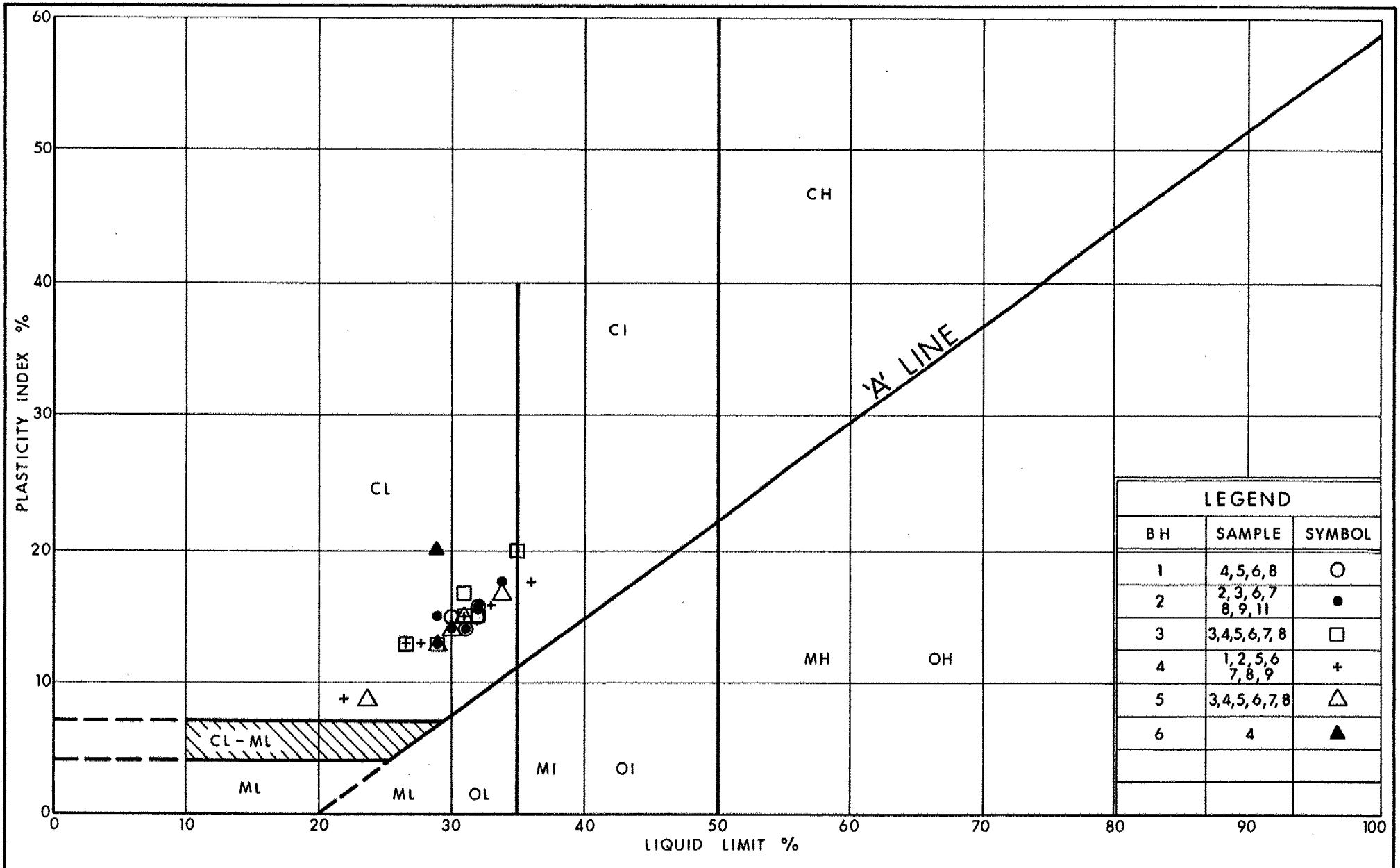
M. Vasavithasan, P. Eng.
Foundation Engineer



T.C. Kim, P. Eng.
Sr. Foundation Engineer

APPENDIX

Oct 75, FF-S-21

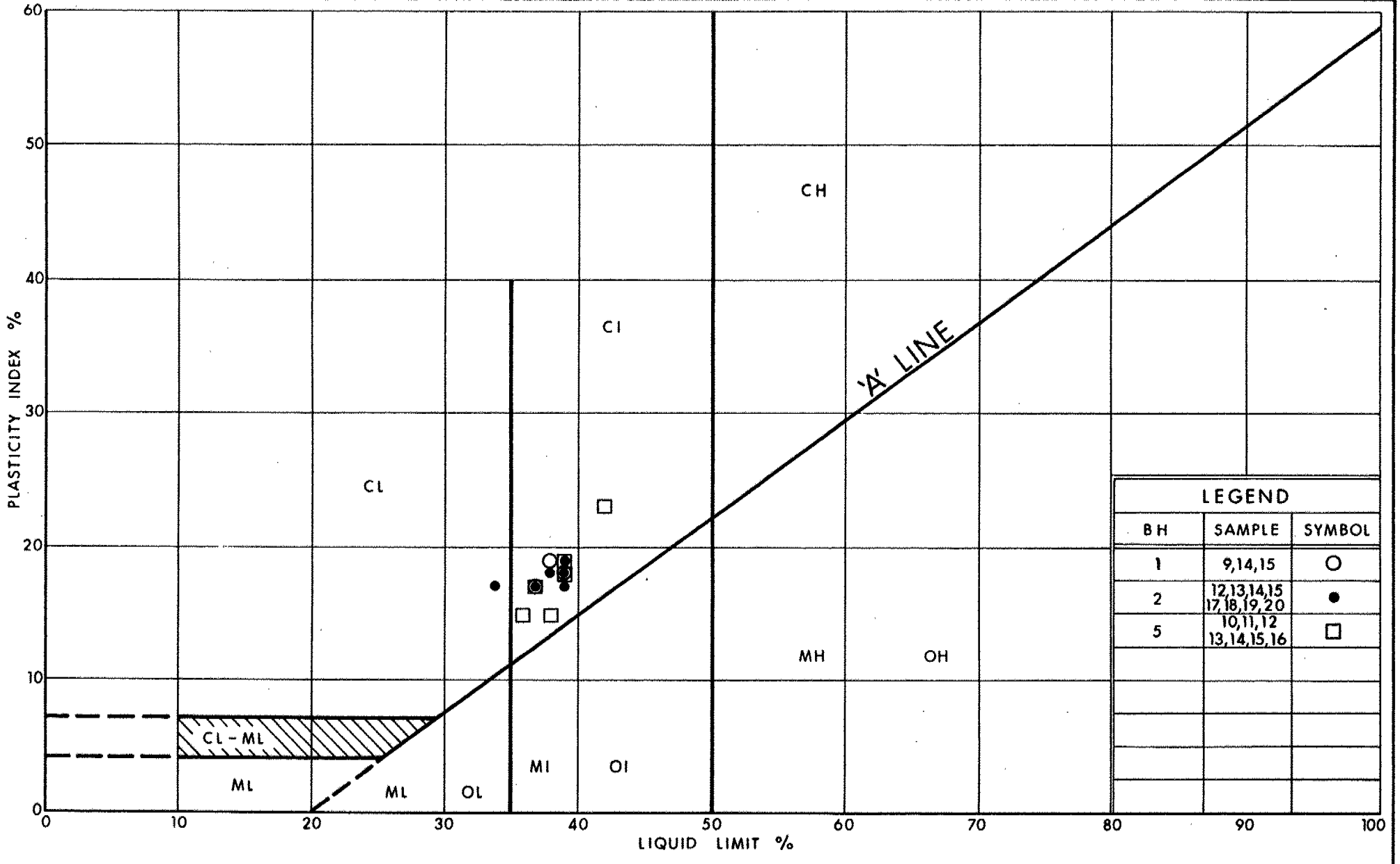


Ministry of Transportation
Ontario

PLASTICITY CHART
CLAYEY SILT
WITH SAND & GRAVEL

FIG No 1

W P 254-91-05



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Ontario

PLASTICITY CHART
SILTY CLAY
WITH SAND & GRAVEL

FIG No 2
W P 254-91-05

RECORD OF BOREHOLE No 1 — 1 OF 2 — METRIC

W.P. 254 – 91 – 05 LOCATION Co-ords: N 4 757 080.0 ; E 317 366.2 ORIGINATED BY T F W

DIST 1 HWY 40 BOREHOLE TYPE 127 mm DIA. AUGER COMPILED BY M V

DATUM GEODETIC DATE 1963 01 29 CHECKED BY T K

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS
188.8	Ground Surface					
0.0	CLAYEY SILT to SILTY CLAY, Heterogeneous Very Stiff to Soft (Fill)		1	SS	24	
186.1			2	SS	4	
2.7	CLAYEY SILT, With Sand and Gravel, Hard to Stiff		3	SS	42	
			4	SS	22	
			5	TW	PH	
			6	TW	PH	
			7	TW	PH	
			8	TW	PH	
176.9						
11.9			9	TW	PH	
			10	SS	26	
			11	SS	27	
			12	SS	22	
			13	SS	26	
			14	SS	27	
	SILTY CLAY, With Sand and Gravel, Very Stiff		15	SS	22	
			16	TW	PH	
158.3						
30.5	Continued					

ELEVATION SCALE: 188, 186, 184, 182, 180, 178, 176, 174, 172, 170, 168, 166, 164, 162, 160

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
- ○ UNCONFINED
- ● QUICK TRIAXIAL
- + FIELD VANE
- × LAB VANE

20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

ELEV	UNIT WEIGHT
182	20.1
180	20.9
178	20.1
176	20.1

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

+³, ×⁵ : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

Continued

RECORD OF BOREHOLE No 1 2 OF 2 METRIC

W.P. 254 - 91 - 05 LOCATION Co-ords: N 4 757 080.0 ; E 317 366.2 ORIGINATED BY T F W

DIST 1 HWY 40 BOREHOLE TYPE 127 mm DIA AUGER COMPILED BY M V

DATUM GEODETIC DATE 1963 01 29 CHECKED BY T K

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
158.3	Continued										
30.5	SILTY CLAY, With Sand and Gravel, Very Stiff		17	SS	23		158				
							156				
							154				
							152				
150.7											
38.1	End of Borehole Probable Bedrock										

*Note: Formerly BH #1 of W. P. 53 - 63

$+^{3}$, $\times^{5}$: Numbers refer to Sensitivity

$15\frac{20}{10}5$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 2 1 OF 2 METRIC

W.P. 254 - 91 - 05 LOCATION Co-ords: N 4 757 060.3 ; E 317 381.7 ORIGINATED BY T F W

DIST 1 HWY 40 BOREHOLE TYPE 127 mm DIA. AUGER COMPILED BY M V

DATUM GEODETIC DATE 1963 02 01 CHECKED BY T K

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
187.1	Ground Surface							
0.0			1	SS	18	▼		
			2	TW	PH		20.9	
			3	SS	42		20.9	
			4	TW	PH			
			5	SS	25		20.1	
			6	TW	PH			
	CLAYEY SILT, With Sand and Gravel, Hard to Stiff		7	TW	PH		19.3	
			8	TW	PH		19.6	
			9	TW	PH		19.6	
			10	TW	PH			
175.2			11	TW	PH		19.6	
11.9			12	TW	PH		20.4	
			13	TW	PH		20.4	
			14	TW	PH		20.3	
	SILTY CLAY, With Sand and Gravel, Very Stiff to Stiff		15	TW	PH		19.8	
			16	TW	PH			
			17	TW	PH		20.3	
			18	TW	PH		19.2	
156.6			19	TW	PH		19.6	
30.5	Continued							

ELEVATION SCALE: 186, 184, 182, 180, 178, 176, 174, 172, 170, 168, 166, 164, 162, 160, 158

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
o UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 20 40 60

>100

+3, ×5 : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

Continued

RECORD OF BOREHOLE No 2 — 2 OF 2 — METRIC

W.P. 254 - 91 - 05 LOCATION Co-ords: N 4 757 060.3 ; E 317 381.7 ORIGINATED BY T F W

DIST 1 HWY 40 BOREHOLE TYPE 127 mm DIA. AUGER COMPILED BY M V

DATUM GEODETIC DATE 1963 02 01 CHECKED BY T K

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
156.6	Continued										
30.5	SILTY CLAY, With Sand and Gravel, Very Stiff to Stiff		20	TW	PH		156				
							154	o		19.3	
							152				
150.8			21	SS	30 /1cm						
36.3	SHALE BEDROCK						150				
149.3											
37.8	End of Borehole										

Note: Formerly BH #2 of W. P. 53 - 63

$+^{3}$, $\times^{5}$: Numbers refer to Sensitivity

$\frac{20}{15}\diamond\frac{5}{10}$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 3 1 OF 2 METRIC

W.P. 254 - 91 - 05 LOCATION Co-ords: N 4 757 092.2 ; E 317 374.1 ORIGINATED BY T F W

DIST 1 HWY 40 BOREHOLE TYPE 127 mm DIA. AUGER COMPILED BY M V

DATUM GEODETIC DATE 1963 02 07 CHECKED BY T K

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
188.8	Ground Surface							
0.0	CLAYEY SILT to SILTY CLAY, Boulders, Heterogeneous, Firm (Fill)		1	SS	6			
			2	TW	PH	▼	18.7	
186.1								
2.7	CLAYEY SILT, With Sand and Gravel, Hard to Stiff		3	SS	29			
			4	SS	40			
			5	TW	PH		20.7	
			6	TW	PH		20.4	
			7	TW	PH		20.1	
			8	TW	PH		20.1	
176.9								
11.9	SILTY CLAY, With Sand and Gravel		9	TW	PH		20.3	
158.3								
30.5	Continued							

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 20 40 60

ELEVATION SCALE 188 186 184 182 180 178 176 174 172 170 168 166 164 162 160

+³, ×⁵ : Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

Continued

RECORD OF BOREHOLE No 3 2 OF 2 METRIC

W.P. 254 - 91 - 05 LOCATION Co-ords: N 4 757 092.2 ; E 317 374.1 ORIGINATED BY T F W

DIST 1 HWY 40 BOREHOLE TYPE 127 mm DIA. AUGER COMPILED BY M V

DATUM GEODETIC DATE 1963 02 07 CHECKED BY T K

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
158.3	Continued										
30.5	SILTY CLAY, With Sand and Gravel						158 / 156 / 154 / 152				
150.7											
38.1	End of Borehole Probable Bedrock										

* Note: Formerly BH #5 of W. P. 53 - 83

+3, ×5 : Numbers refer to Sensitivity

15 20/10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 4 1 OF 2 METRIC

W.P. 254 - 91 - 05 LOCATION Co-ords: N 4 757 125.0 ; E 317 395.8 ORIGINATED BY T F W

DIST 1 HWY 40 BOREHOLE TYPE 127 mm DIA. AUGER COMPILED BY M V

DATUM GEODETIC DATE 1963 02 08 CHECKED BY T K

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
187.5	Ground Surface										
0.0			1	SS	14		186				
			2	SS	31						
			3	SS	37		184				
			4	TW	PH	▼				20.6	
	CLAYEY SILT, With Sand and Gravel, Hard to Stiff		5	TW	PH		182			20.7	
			6	TW	PH		180			19.6	
			7	TW	PH		178			20.1	
			8	TW	PH		176			20.1	
175.5			9	TW	PH			>100 +		20.4	
12.0	SILTY CLAY, With Sand and Gravel						174				
							172				
							170				
							168				
							166				
							164				
							162				
							160				
							158				
157.0											
30.5	Continued										Continued

$+^3$, $\times^5$: Numbers refer to Sensitivity

20 / 15 ◇ 5 (%) STRAIN AT FAILURE / 10

RECORD OF BOREHOLE No 4 2 OF 2 METRIC

W.P. 254 - 91 - 05 LOCATION Co-ords: N 4 757 125.0 ; E 317 395.8 ORIGINATED BY T F W

DIST 1 HWY 40 BOREHOLE TYPE 127 mm DIA. AUGER COMPILED BY M V

DATUM GEODETIC DATE 1963 02 08 CHECKED BY T K

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
157.0	Continued										
30.5	SILTY CLAY, With Sand and Gravel						156 154 152				
150.8											
36.7	End of Borehole Probable Bedrock										

* Note: Formerly BH #6 of W. P. 53 - 63

$+^{3}$, $\times^{5}$: Numbers refer to Sensitivity

$15 \overset{20}{\underset{10}{\diamond}} 5$ (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 5 1 OF 2 METRIC

W.P. 254 - 91 - 05 LOCATION Co-ords: N 4 757 135.4 ; E 317 399.6 ORIGINATED BY T F W

DIST 1 HWY 40 BOREHOLE TYPE 127 mm DIA. AUGER COMPILED BY M V

DATUM GEODETIC DATE 1963 02 11 CHECKED BY T K

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						GR SA SI CL
187.5 / 0.0	Ground Surface										
	CLAYEY SILT, With Sand and Gravel, Hard to Stiff		1	TW	PH	▼	186				
			2	TW	PH						
			3	TW	PH		184	>100		20.1	
			4	TW	PH			+2		20.9	
			5	TW	PH		182	-3		20.1	
			6	TW	PH		180	+2		20.3	
			7	TW	PH			+3		20.1	
			8	TW	PH		178	+2		20.1	
173.8 / 13.7			9	TW	PH		176			20.1	
	SILTY CLAY, With Sand and Gravel, Very Stiff to Stiff		10	TW	PH		174			20.1	
			11	TW	PH		172			19.8	
			12	TW	PH		170			19.6	
			13	TW	PH		168			19.5	
			14	TW	PH		166			19.5	
157.0 / 30.5	Continued						164				
							162				
							160				
							158				

Continued

$+^3$, $\times^5$: Numbers refer to Sensitivity

20 / 15 ◇ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 5 2 OF 2 METRIC

W.P. 254 - 91 - 05 LOCATION Co-ords: N 4 757 135.4 ; E 317 399.6 ORIGINATED BY T F W

DIST 1 HWY 40 BOREHOLE TYPE 127 mm DIA. AUGER COMPILED BY M V

DATUM GEODETIC DATE 1983 02 11 CHECKED BY T K

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
157.0 / 30.5	Continued										
	SILTY CLAY, With Sand and Gravel, Very Stiff to Stiff		15	TW	PH		156	o		19.8	
							154				
			16	TW	PH			o		19.5	
							152				
150.6											
150.3	SHALE BEDROCK										
37.2	End of Borehole										

*Note: Formerly BH #7 of W. P. 53 - 63

$+^3$, $\times^5$: Numbers refer to Sensitivity

$\frac{20}{15 \diamond 5}$ (%) STRAIN AT FAILURE
$\frac{}{10}$

RECORD OF BOREHOLE No 6 1 OF 1 METRIC

W.P. 254 - 91 - 05 LOCATION Co-ords: N 4 757 140.3 ; E 317 369.5 ORIGINATED BY T F W

DIST 1 HWY 40 BOREHOLE TYPE 127 mm DIA. AUGER COMPILED BY M V

DATUM GEODETIC DATE 1963 02 11 CHECKED BY T K

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
187.5	Ground Surface										
0.0						*					
			1	SS	27		186				
			2	SS	36						
	CLAYEY SILT, With Sand and Gravel, Hard to Stiff						184				
			3	TW	PH						20.7
							182				
			4	TW	PH						20.0
							180				
			5	SS	9						
178.2			6	SS	21						
9.3	End of Borehole										

* Note:
Formerly BH #8 of
W. P. 53 - 63
Water Level Not Established

$+^{3}$, $\times^{5}$: Numbers refer to Sensitivity

$15 \frac{20}{10} 5$ (%) STRAIN AT FAILURE

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS $\bar{N}$.

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	>200
	VERY SOFT	*SOFT*	*FIRM*	*STIFF*	*VERY STIFF*	*HARD*

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	>50
	VERY LOOSE	*LOOSE*	*COMPACT*	*DENSE*	*VERY DENSE*

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	*POOR*	*FAIR*	*GOOD*	*EXCELLENT*

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	>3m
JOINTING	*VERY CLOSE*	*CLOSE*	*MOD. CLOSE*	*WIDE*	*VERY WIDE*
BEDDING	*VERY THIN*	*THIN*	*MEDIUM*	*THICK*	*VERY THICK*

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

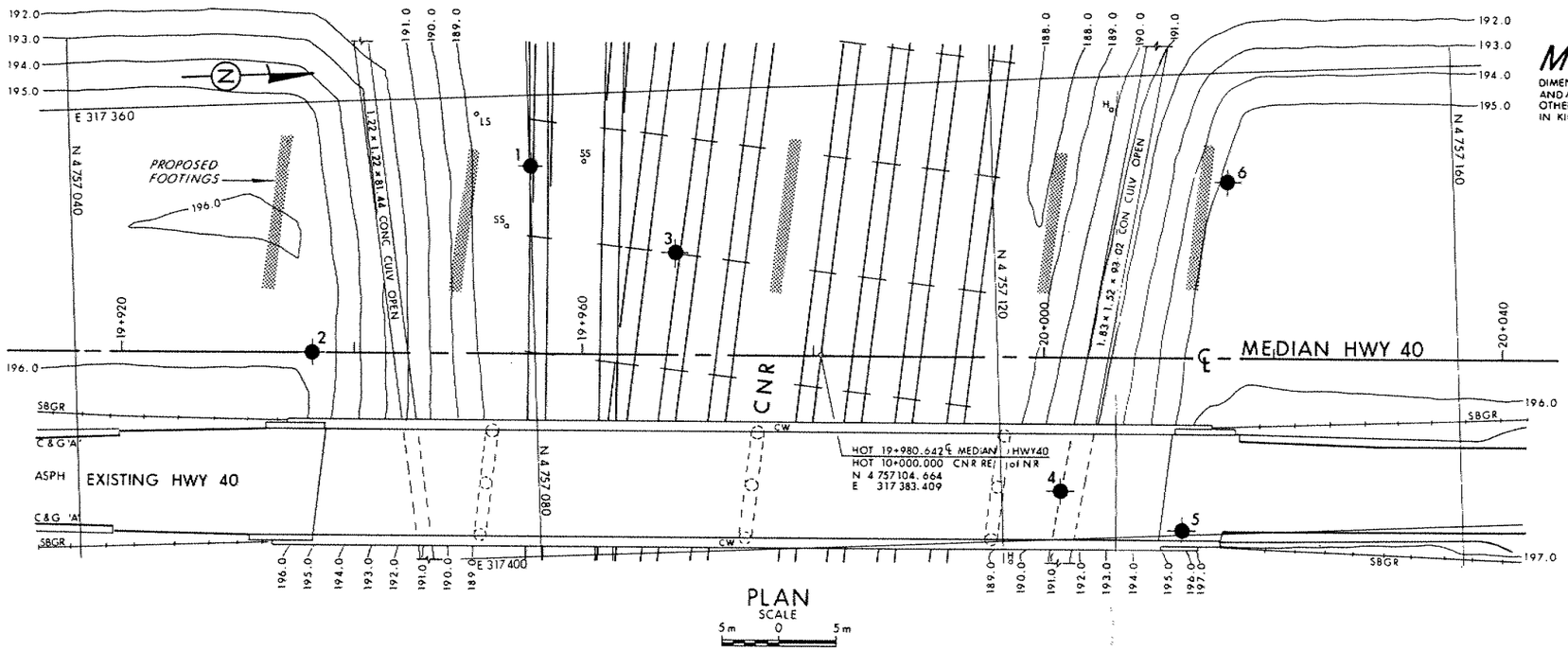
PHYSICAL PROPERTIES OF SOIL

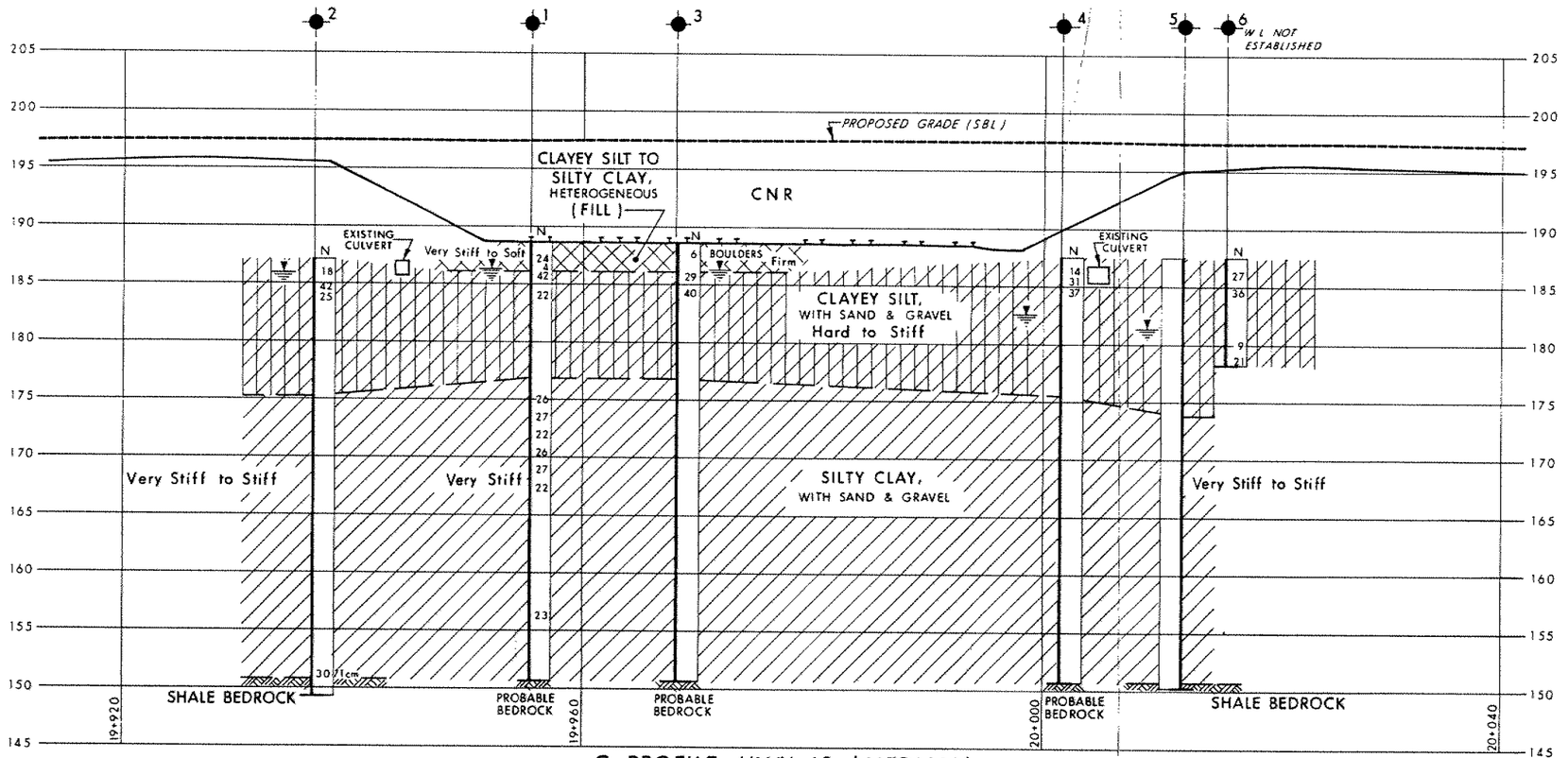
ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL

e	1,%	VOID RATIO
n	1,%	POROSITY
w	1,%	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_p	%	PLASTIC LIMIT
w_S	%	SHRINKAGE LIMIT
I_p	%	PLASTICITY INDEX = $w_L - w_p$
I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$
I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$
e_{max}	1,%	VOID RATIO IN LOOSEST STATE

e_{min}	1,%	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_U	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

MINISTRY OF TRANSPORTATION, ONTARIO PH-0-207 88 10





METRIC

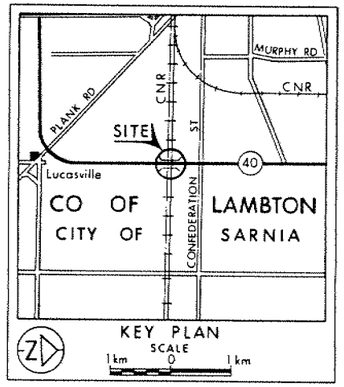
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No
WP No 254-91-05

CAN NAT RWY OVERHEAD

BORE HOLE LOCATIONS & SOIL STRATA

SHEET



LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W L at time of investigation 1963 01 and 02

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	188.8	4 757 080.0	317 366.2
2	187.1	4 757 060.3	317 381.7
3	188.8	4 757 092.2	317 374.1
4	187.5	4 757 125.0	317 395.8
5	187.5	4 757 135.4	317 399.6
6	187.5	4 757 140.3	317 369.5

NOTE

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section GC 2.01 of OPS Gen.Cond.

REV	DATE	BY	DESCRIPTION

Geocres No 40J16-61

LICENSED PROFESSIONAL ENGINEER M. YASAVITHASAN PROVINCE OF ONTARIO

HWY No 40 (SBL)			DIST 1
SUBM'D MV	CHECKED	DATE 1994 09 30	SITE 14-290/2
DRAWN RS	CHECKED	APPROVED	DWG 2549105-A

REF No E-179-40-1; 1994 02